Navy Personnel Research and Development Center
San Diego, California 92152-7250 TN-96-34 March 1996

Cost/Benefits Analysis of Interactive Electronic Technical Manuals/Automated Classroom (IETM/AC) Technology

Linda J. Mark
H. Dewey Kribs
Barbara A. Morris
David K. Dickason

DTIC QUALITY INSPECTED 3

19960417 133

Approved for public release; distribution is unlimited.

NPRDC-TN-96-34 March 1996

Cost/Benefits Analysis of Interactive Electronic Technical Manuals/Automated Classroom (IETM/AC) Technology

Linda J. Mark
H. Dewey Kribs
Instructional Science and Development, Inc.
Pensacola, FL

Barbara A. Morris
David K. Dickason
Navy Personnel Research and Development Center
San Diego, CA

Reviewed by
Orvin Larson

Approved and released by
J. C. McLachlan
Director, Classroom and Afloat Training

DTIC QUALITY INSPECTED 3

Navy Personnel Research and Development Center
53335 Ryne Road
San Diego, CA 92152-7250

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATE COVERED
	March 1996	Final--1 Feb 95-15 Sep 95

4. TITLE AND SUBTITLE
Cost/Benefits Analysis of Interactive Electronic Technical Manuals/Automated Classroom (IETM/AC) Technology

5. FUNDING NUMBERS
Program Element: N66001-91-D-9502
Work Unit:

6. AUTHOR(S)
Linda J. Mark, H. Dewey Kribs, Barbara A. Morris, David K. Dickason

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Navy Personnel Research and Development Center
53335 Ryne Road
San Diego, CA 92152-7250

8. PERFORMING ORGANIZATION REPORT NUMBER
NPRDC-TN-96-34

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Chief of Naval Personnel (PERS-00H)
Navy Annex
Washington, DC 20350

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Functional Area: Training Systems Technology
Product Line: Classroom and Afloat Training
Product Line: Automated Classroom

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 words)*

The Navy Personnel Research and Development Center (NPRDC), working with the Naval Sea Systems Command (NAVSEA) and Chief of Naval Education and Training (CNET), completed a program of research, development, and evaluation for automating classroom activities in which interactive electronic technical manuals (IETMs) are used. The project addressed two Navy training problems: (1) the need to utilize emerging technologies to improve maintenance performance and reduce maintenance costs and (2) the need to improve the efficiency of the Navy training pipeline. These problems are being addressed by combining IETM technology with an integrated electronic multimedia editing and delivery system.

The cost/benefits analysis determined the costs associated with the IETM/AC system and assessed the benefits of the advanced training technology implemented in the Gas Turbine C School, Service School Command, Great Lakes, IL. This report is directed to training communities and program managers who may be developing similar automated systems.

Benefits identified during this analysis include improved student performance, reduction in student training costs, and reduction in course reproduction costs.

14. SUBJECT TERMS
Electronic classroom, classroom training, instructional technology, cost/benefits analysis, interactive electronic technical manual (IETM)

15. NUMBER OF PAGES
72

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

Foreword

The Interactive Electronic Technical Manual/Automated Classroom (IETM/AC) Technology project was sponsored by the Bureau of Naval Personnel under Program Element 0603707N. This cost/benefits analysis was completed under the Navy Personnel Research and Development Center Contract N66001-91-D-9502. The objective was to evaluate the impact of the automated classroom on student performance, course content and length, as well as cost issues.

The cost/benefits analysis determined the costs associated with the IETM/AC system and assessed the benefits of the advanced training technology implemented in the Gas Turbine "C" School, Service School Command, Great Lakes, IL. This report is directed to training communities and program managers who may be developing similar automated systems.

J. C. McLACHLAN
Director, Classroom and Afloat Training

Summary

Background

Navy Personnel Research and Development Center (NPRDC), working with the Naval Sea Systems Command (NAVSEA) and Chief of Naval Education and Training (CNET), completed a program of research, development, and evaluation for automating classroom activities in which interactive electronic technical manuals (IETMs) are used. The project addresses two Navy training problems: (1) the need to utilize emerging technologies to improve shipboard maintenance performance and reduce maintenance costs, and (2) the need to improve the efficiency of the Navy training pipeline.

Objective

This study determines the costs associated with the IETM/AC system and assesses the costs/ benefits of the advanced training technology implemented in the GS "C" School at Service School Command, Great Lakes, IL.

Approach

The cost/benefits analysis process followed guidelines provided by Naval Education and Training Program Management Support Activity (NETPMSA) for an Abbreviated System Decision Paper (ASDP). The ASDP is a tool that is currently used by schools in the CNET chain of command to obtain support, funding, and approval for small information system projects. The process included analysis of (1) course characteristics and potential benefits if automated, (2) trade-offs in course/school management requirements for course conversion, (3) delivery system capabilities, (4) interface considerations for configuration, (5) non-recurring and recurring cost estimates for implementation of the IETM/AC, and (6) quantifiable and non-quantifiable benefits resulting from implementation of the IETM/AC.

Results

Benefits identified during this analysis include improved student performance, reduction in student training costs, and reduction in course reproduction costs.

Initial data indicated a slight improvement in student performance scores in the IETM-based courses over student performance scores in the paper-based courses. These preliminary results suggest that introduction of the IETM/AC technology and subsequent reduction in course length has not had an adverse effect on student performance.

The elimination of 7 training weeks from the GSE pipeline and 3 training weeks from the GSM pipeline results in a reduction in student training costs of over $1,900,000 for FY 95 and FY 96.

The cost savings for not reproducing the paper-based technical manuals used in the GSE/GSM courses is estimated at over $96,000 for FY 96.

Conclusions

Adequate planning is key to successful implementation of the IETM/AC. Institutional impacts, life cycle management, roles and responsibilities of personnel, user training, the hardware and software acquisition planning, appropriateness of a course for automation, and impact on the instructors and students need to be addressed early in the development process.

Benefits in both preparing and delivering instruction may be realized by incorporating the Training Integration Management Software (TIMS), currently under evaluation in a Diesel Division course at Great Lakes. TIMS will accommodate instructional materials from a variety of sources including the Authoring Instructional Materials (AIM) system, Standard Generalized Markup Language (SGML) editors, and common PC word processors.

Recommendations

The GSE/GSM demonstration highlights the need for coordination among Navy commands and organizations. As the IETM/AC technology evolves and costs decrease, more systems in the fleet will be targeted for IETM development and more formal courses in the schoolhouses will be identified for conversion to the IETM/AC format. The roles and responsibilities of cognizant organizations should be well defined and procedures established to ensure coordination.

To accommodate the Program Objective Memorandum (POM) budgeting cycle, the current time line for submission of both an Equipment Facilities Requirement Plan (EFRP) and an Abbreviated System Decision Paper (ASDP) is 6 years prior to project implementation. Considering the rapid advances in technology, a shorter time frame between project initiation and subsequent funding and implementation should be established.

The formal Instructor Training Schools should be revised to provide training in topics such as computer literacy and operator skills, techniques for designing and presenting computer-based instructional media, use of automated performance assessment tools, and technology-driven instructional strategies.

The automated classroom technology imposes new skill requirements for management and support personnel. The possibility of establishing a formal school to produce a Navy version of an industry certified information system manager and network administrator should be investigated.

Contents

		Page
Section One: Introduction		1
1.1	Problem	3
1.2	Objective	3
1.3	Background	4
1.3.1	Scope of the NAVSEA Effort	4
1.3.2	Scope of the NPRDC Effort	7
1.4	Report Organization	8
Section Two: Approach:		9
2.1	Review of Literature	11
2.2	Rationale	11
2.3	Methodology	13
Section Three: Cost/Benefits Analysis Process		17
3.1	Overview	19
3.2	Analysis of Course Characteristics	19
3.3	Analysis of Trade-offs in Course Management Requirements	22
3.4	Analysis of Course Conversion Requirements	27
3.4.1	Conversion Process	27
3.4.2	Cost Estimating Parameters	29
3.5	Analysis of Delivery System Capabilities	29
3.6	Analysis of Interface Considerations	30
3.6.1	Facilities	30
3.6.2	Testing and Security	30
3.6.3	Hardware/Equipment Acquisition and Maintenance	31
3.6.4	Networking	31
3.6.5	Software Acquisition and Upgrades	31
3.6.6	Personnel Training/Logistic Support	32
3.7	Development of Non-Recurring and Recurring Cost Estimates	32
3.7.1	Non-Recurring Cost Elements	35
3.7.2	Recurring Cost Elements	37
3.8	Identification of Benefits	38
Section Four: Costs/Benefits Model		41
4.1	Scope	43
4.2	Statement of Benefits	44
4.2.1	Benefit: Improvements in Student Performance Scores	45
4.2.2	Benefit: Reduction in Student Training Costs	46

Page

4.2.3 Benefit: Reduction in Course Reproduction Costs 48
4.3 Life Cycle Cost Model: Non-Recurring Costs 49
4.3.1 Student Station 51
4.3.2 Instructor Station 52
4.3.3 Local Area Network 53
4.3.4 LiveBoard 53
4.3.5 Link System 54
4.3.6 Classroom Preparation 55
4.3.7 Hardware Installation 55
4.3.8 User Training 55
4.3.9 Course Conversion 55
4.4 Life Cycle Cost Model: Recurring Cost Elements 56
4.4.1 Hardware Maintenance 56
4.4.2 Software Maintenance and Enhancements 57
4.4.3 Hardware/Software Upgrades 57
4.4.4 Logistical Support 57
4.4.5 System/Network Administration 58
4.4.6 User Training 58
4.4.7 Course Revision 59

Section Five: Discussion 61

5.1 Implications for Future Implementations 63
5.1.1 Life Cycle Support 63
5.1.2 Acquisition Planning 64
5.1.3 User Training 65
5.1.4 Interface with IETM Database 66
5.2 Potential Benefits 67

Section Six: Recommendations 69

Section Seven: References 73

Section Eight: Distribution List 75

List of Tables

		Page
1.	Analysis of Course Characteristics and Potential Benefits	20
2.	Analysis of Course/Schoolhouse Management Requirements	24
3.	Life Cycle Cost Model: Non-Recurring Costs	34
4.	Life Cycle Cost Model: Recurring Costs	34
5.	Comparison of GSE Student Performance Scores	46
6.	Comparison of GSM Student Performance Scores	46
7.	Student Training Cost Savings for GSE/GSM Courses	47
8.	Reproduction Cost Savings for GSE/GSM Courses	49
9.	GSE/GSM Life Cycle Cost Model: Non-Recurring Costs	51

Section One

Introduction

1.0 Introduction

1.1 Problem

The Interactive Electronic Technical Manual/Automated Classroom (IETM/AC) project is a joint development effort between the Naval Sea Systems Command (NAVSEA) and the Navy Personnel Research and Development Center (NPRDC). The project addresses two Navy training problems: (1) the need to utilize emerging technologies to improve shipboard maintenance performance and reduce maintenance costs, and (2) the need to streamline the Navy training pipeline.

In addition, the project addresses the following Navy training development and delivery problems: (1) the need for a usable system to develop, revise, and deliver multimedia course materials; (2) the need to accommodate a variety of media (text, graphics, audio, video, computer-based) in the classroom; (3) the need to provide instructors with a paperless delivery environment that eliminates large amounts of paper-based training materials and the problems associated with updating them; and (4) the need to enable subject matter experts and instructors with minimal curriculum development or training delivery background to develop, modify, and deliver integrated computerized curriculum materials.

These problems have been addressed by combining IETM technology with an integrated electronic multimedia editing and delivery system. The automated classroom system takes advantage of technologies that use electronic data, permit new ways of creating and delivering classroom instruction, and enable standardized ways of interchanging various electronic forms of texts and graphics. The IETM/AC technology is in use in the Gas Turbine Technician Electrical (GSE) and Gas Turbine Technician Mechanical (GSM) courses taught in the Gas Turbine Technician Journeyman Level Accession Training (GS "C" School) at Service School Command, Great Lakes, IL (SSC GLAKES).

1.2 Objective

As information technology evolves and becomes cheaper, more systems in the fleet are being targeted for IETM development and more formal courses in the schoolhouses are being identified for conversion to an IETM/AC format. Procedures for acquiring and logistically supporting IETM/AC technology in the schoolhouses are essential. Otherwise, the funding and support for the technology may not be there. However, a methodology for analyzing the costs and benefits of implementing the technology needs to be incorporated into the decision making process.

This study determines the costs associated with the IETM/AC system and assesses the costs/benefits of the advanced training technology implemented in the GS "C" School at SSC GLAKES. The contractor, Instructional Science and Development, Inc. (ISD, Inc.) was tasked to develop a costs/benefits model to:

1. Identify the costs associated with converting conventional instruction to automated instruction using the IETM/AC technology.

2. Analyze the life cycle costs for implementing the IETM/AC technology, including the hardware and software components.

3. Measure any anticipated or actual gains in efficiencies achieved through the implementation of the IETM/AC technology.

1.3 Background

The joint IETM/AC project is a practical and expedient means of combining two concurrent efforts, one by NAVSEA and one by NPRDC, to accomplish the goals of both projects. In August 1994, the Implementation Planning Group, co-chaired by the Chief of Naval Education and Training (CNET N5123) and the Naval Sea Systems Command (NAVSEA 04PT), developed a project Evaluation and Implementation Plan (EIP) for the joint project.

As stated in the EIP, the objective of the project is to develop and evaluate an automated classroom that incorporates IETM technology. The overall goal is to demonstrate the feasibility of the IETM/AC technology for developing, revising, and delivering Navy instruction. NAVSEA is responsible for the technical applications of IETMs in the classroom, while NPRDC is responsible for evaluating the efficiencies of an automated classroom, examining the usefulness of specific training enhancements that are not currently available in the IETM automated classroom, and developing a curriculum decision algorithm. Together NAVSEA and NPRDC will develop system specifications and recommendations for implementing the products for additional courses at SSC GLAKES, other Naval Education and Training Command (NAVEDTRACOM) schools, and the AEGIS Training Center.

1.3.1 Scope of the NAVSEA Effort

The objective of the NAVSEA project was to produce an IETM database, which could be used aboard ship and in the schoolhouse, to improve shipboard maintenance performance, decrease maintenance costs, and reduce the volumes of paper technical manuals. The IETM database was designed to support a dynamic interactive technical training environment to enhance training and reduce course length.

As stated by Alligood (1994), NAVSEA selected the gas turbine systems for IETM database development for the following reasons:

1. "Gas Turbine Propulsion Ships will comprise one-third of the Navy at this decade's end-wide applicability!" (pg. 1).

2. There is a need to improve maintenance performance and reduce maintenance costs. Gas turbine systems are the most expensive set of systems in the Navy to maintain in terms of ownership costs and ship man hours. IETM demonstration projects have shown more accurate troubleshooting, better diagnostics by technicians, less time to perform maintenance tasks, and the ability of inexperienced technicians to perform maintenance at a level comparable to experienced technicians when using an IETM.

3. Since all of the gas turbine systems are mature, the IETM would be based on legacy data. The development approach would include all technical information/documentation for the systems as well as the GS "C" School training curricula. Gas turbine systems encompass multiple equipments, with numerous configurations, installed in multiple ship classes.

4. There is a need to reduce the GSE and GSM training pipelines to avoid and/or save training costs. The GSE training pipeline (including console operator training) is approximately 23 weeks, while the GSM training pipeline (including console operator training) is 20 weeks. The IETM demonstration for the AN/BSY-2 Combat Systems is an example of the potential training benefits (33% reduction in the number of training courses and a 28% reduction in the number of training days) that can be realized.

Under the direction of NAVSEAs Technical Data Division (SEA 04TD), the following organizations participated in the development of the GS IETM database: (1) the prime contractor, Lockheed/Martin (formerly Martin Marietta, Ocean Systems Division), (2) the Gas Turbine Systems In-Service Engineering Activity (GS ISEA), Naval Surface Warfare Center, Carderock Division, Philadelphia Detachment (NAVSSES), and (3) New Technologies Division personnel and GS "C" school instructional staff at SSC GLAKES. The GS IETM development process followed the approach Lockheed/Martin used in developing the AN/BSY-2 Combat Systems IETM. The process, as illustrated in Figure 2, takes advantage of best commercial practices for data conversion and CALS (Continuous Acquisition and Life Cycle Support) compliant tagging in SGML (Standard Generalized Mark-up Language) and best commercial practices for data translation, integration, hyperlinking, and display.

Over 110,000 pages of technical information/documentation were converted and SGML tagged during the development of the GS IETM. NAVSEA developed the Document Type Definitions (DTD). The DTD consists of a set of SGML tags (developed in compliance with MIL-M-28001B, August 1993) that were used to tag data to the paragraph level as the smallest object of data converted. Diagrams, figures, and tables were also SGML object tagged. The converted data was uploaded into an object oriented common IETM database using relational database management software. The common database consists of two files--the file containing all of the text and graphics and the object ID file containing the SGML tags.

To create IETM functionality for performing shipboard maintenance, view packages for general knowledge, troubleshooting, maintenance, and operations were developed by subject matter experts (SMEs). Each view package is a script that sets the flow from one object, such as a paragraph, graphic or table, to another that the SMEs consider the best approach to accomplish a procedure or task, such as troubleshooting a specific piece of equipment. The SMEs, consisting of personnel from SSC GLAKES (New Technologies Division and GS "C" school instructors) and NAVSSES (GS ISEA), were trained in view package authoring techniques by Lockheed/Martin staff. Development of the view packages was not difficult, but it was labor intensive and required several months of effort.

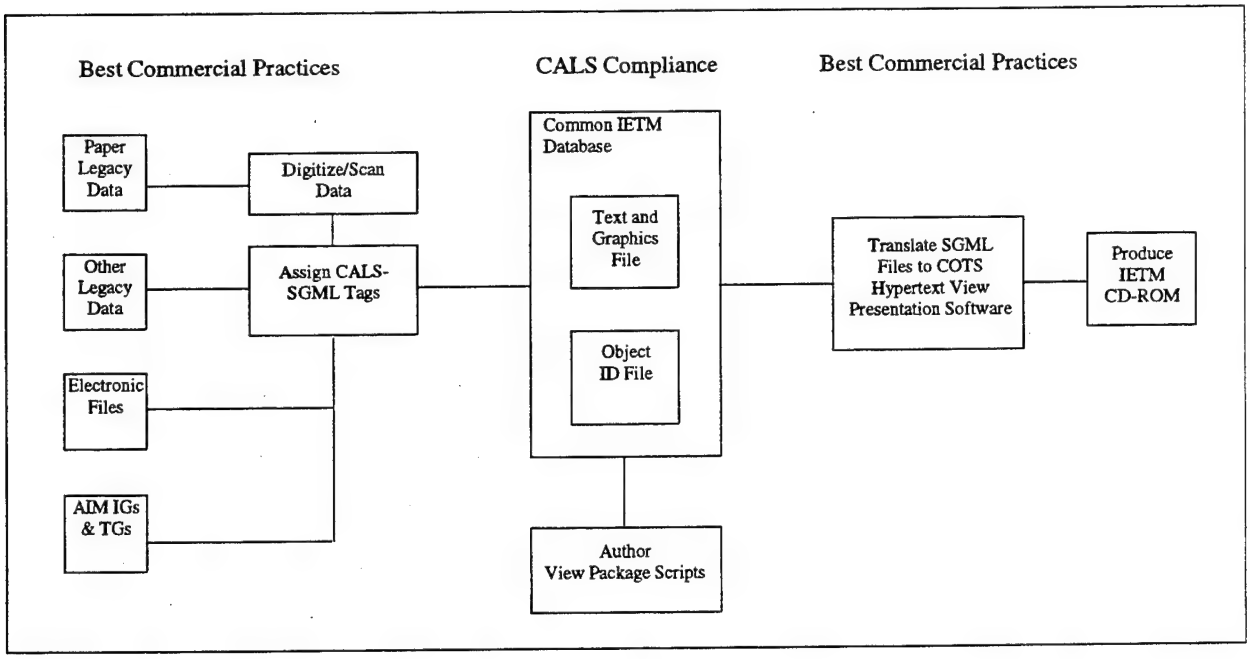

Figure 1. The gas turbine IETM development process.

The view packages were authored by linking, in script format, the object file IDs (SGML tags) and applying content data model (CDM) SGML tags (defined in MIL-M-87269, November, 1992). View package scripts contained commands to link and/or launch to other applications such as video, audio, animations, and other documentation on compact disk. The scripted information was uploaded via an ASCII text editor to the common IETM database to provide positive linkage of data in native SGML format. Lockheed/Martin then processed the database through a translator for presentation using commercial-off-the-shelf (COTS) hypertext/hyperlink software (InfoAccess GUIDE). The IETM database was mastered on CD-ROM for distribution to the fleet and the schoolhouse to be displayed on COTS personal computer hardware.

A Memorandum of Agreement between NAVSEA and SSC GLAKES gave NAVSEA the responsibility for developing the electronically enhanced Instructor Guides (IGs) and Trainee Guides (TGs) for inclusion in the IETM database. In addition to the view package development effort, personnel from the New Technologies division and the GSE/GSM instructional staff were also rewriting the conventional paper-based curricula for inclusion in the IETM database. Rather than revising the courses in Word Perfect and then converting them over to AIM (Authoring Instructional Materials), the Navy's current system for authoring PPP-based (Personnel Performance Profiles) instruction, the revised IGs and TGs were authored using AIM. The AIM databases were provided to Lockheed/Martin to extract and convert the training materials to SGML format for inclusion in the IETM database. The IGs and TGs have the capability to search and launch to associated multimedia materials such as video, audio, and graphics for classroom presentation that are not in the IETM database.

NAVSEA acquired and installed the hardware and software for five automated classrooms in the GS "C" School to evaluate the effectiveness of the IETM technology in the formal school setting.

1.3.2 Scope of the NPRDC Effort

The objective of the NPRDC effort was to develop a prototype system for developing, revising, managing, and delivering multimedia course materials that is tied to the CNET curriculum development and maintenance infrastructure. NPRDC developed a software system architecture to: (1) allow instructors and other schoolhouse staff, with minimal training, to develop, manage, organize, and deliver different forms of electronic training materials; (2) accommodate a variety of media (computer-based text, graphics, audio, video); (3) provide instructors with a paperless delivery environment, and (4) ensure compatibility with, but not dependence upon, the AIM system.

To accomplish these goals and minimize format differences between AIM and COTS software, the NPRDC software architecture, referred to as the Training Integration Management Software (TIMS), provides several features to augment the NAVSEA IETM classrooms. Currently, CNET schools prepare task-based instructional materials using Word Perfect word processing software and PPP-based instructional materials using AIM. Since the NAVSEA IETM process requires SGML format, the IGs and TGs in the AIM database or in Word Perfect format need to be SGML tagged for inclusion in the IETM database. TIMS provides a format neutral processing capability to electronically present instructional materials from different source formats (i.e., AIM or Word Perfect) in the automated classrooms. It is a software program that uses Windows interprocess communication mechanisms to link media objects (e.g., graphic, text, IETM references, animations, audio, video) without regard to their data format. It is designed to allow curriculum developers and instructors to link media objects to IG paragraphs without SGML tagging.

TIMS has three modes. Each mode supports different functions that Navy personnel must perform. In the annotation mode, it allows curriculum developers to attach current, standardized annotations (such as IETM references) that all of the instructors will present in the classroom. In the personalization mode, it allows an individual instructor to attach personal annotations (text notes as well as other media) to IG paragraphs in the Related Instructional Activity (RIA) column for use in the classroom. In the classroom mode, it supports the automated classroom presentation by including a programmable remote control capability to allow the instructor to control classroom presentation from anywhere in the room. It also allows the instructor to digitally broadcast video displays to student stations without the analog switches used in the NAVSEA IETM classrooms.

In addition to the demonstration of TIMS, NPRDC was also tasked to evaluate the effectiveness and efficiencies of the IETM automated classrooms at SSC GLAKES. The evaluation variables include: (1) a comparison of student performance scores between the paper-based and the IETM-based GSE/GSM courses, (2) a comparison of course content and length between the paper-based and the IETM based GSE/GSM courses, (3) instructor and student control issues in the IETM/AC classroom, (4) the impact of the IETM/AC technology on management and the institution, and (5) the impact of the IETM/AC technology on costs and time associated with running a traditional classroom.

The costs/benefits analysis presented in this report is one aspect of the evaluation that NPRDC is conducting of the IETM/AC implementation at the GS "C" School at SSC GLAKES. NPRDC may use the results of this study to assist in developing the curriculum decision algorithm and providing implementation recommendations.

1.4 Report Organization

The remainder of this report is organized into the following sections.

1. Approach--a discussion of the review of literature and a summary of the rationale and methodology developed in the study for analyzing the costs and benefits of implementing the IETM/AC technology.

2. Costs/Benefits Analysis Process--a detailed description of the costs/benefits analysis process we developed for decision makers considering implementation of the IETM/AC technology.

3. Costs/Benefits Model--the results of the costs/benefits analysis for implementing the IETM/AC technology in the GS "C" School at SSC GLAKES.

4. Discussion--a discussion of the R&D effort and the implications for future implementation of the IETM/AC technology.

5. Recommendations--a list of suggestions for implementing the IETM/AC technology in NAVEDTRACOM schools in the future.

Section Two

Approach

2.0 Approach

2.1 Review of Literature

A review of cost analysis techniques was conducted to identify the best approach for analyzing the costs and benefits associated with the IETM/AC technology. Within the socio-political context of educational evaluation, the term cost analysis refers to the use of a broad set of techniques for evaluation and decision making, including cost-effectiveness, cost-benefit, cost-utility, and cost-feasibility (Levin, 1983). Although these terms are used interchangeably, each approach has specific applications. The following definitions are offered by Levin (1983):

1. Cost-effectiveness analysis refers to the evaluation of alternatives according to both their costs and their effects with regard to producing some outcome or set of outcomes. To be selected, an alternative must provide either maximum effectiveness for a set level of cost or least cost for a set level of effectiveness.

2. Cost-benefit analysis refers to the evaluation of alternatives according to a comparison of both their costs and benefits when each is measured in monetary terms. To be selected an alternative must show benefits in excess of costs.

3. Cost-utility analysis refers to the evaluation of alternatives according to a comparison of their costs and the estimated utility or value of their outcomes. This technique permits the use of a wide range of qualitative and quantitative data to be included in the evaluation.

4. Cost-feasibility analysis refers to the method of estimating only the costs of an alternative to determine whether or not it exceeds the budget and other resources that are available.

The objectives of this study fit within the definition of cost-benefit analysis. A definitive approach to cost-benefit analysis is provided in the DoD Handbook for Economic Analysis (2nd edition). This handbook provides detailed guidelines on the process and procedures for estimating costs, judging benefits, and comparing alternatives. However, the data requirements for performing an economic analysis are far more stringent than the data that was available from this project. For example, sufficient data to specify alternative configurations and derive the costs and benefits for each of the alternatives was not available at this point in the ongoing evaluation. In addition, the effort required to perform an economic analysis was beyond the scope of the effort proposed for this study. Since following the traditional cost-benefit analysis techniques was not feasible, we looked for another framework for analyzing the costs and benefits of implementing the IETM/AC technology in NAVEDTRACOM schools.

2.2 Rationale

After discussions with Navy personnel in different organizations, we selected the requirements of the Abbreviated System Decision Paper (ASDP) as the basis of our approach for analyzing the costs and benefits of implementing the IETM/AC technology. The ASDP is a tool that is currently used by schools in the CNET chain of command to obtain support, funding, and

approval for small information system projects. Since the format for an ASDP includes a statement of costs and benefits, it is relevant to the issues in this study.

In February 1994, the Naval Education and Training Program Management Support Activity (NETPMSA, Code 0634) issued a revised set of guidelines for automated data processing (ADP) personnel and non-ADP end users to use in preparing an ASDP. These guidelines amplify the information contained in SECNAV Instruction 5231.1C, Appendix A to Enclosure (2), and CNET Instruction 5231.1B. It specifies the abbreviated life cycle management (LCM) documentation needed for acquisition of microcomputers, local area networks, and multimedia hardware and software. It provides guidance from project initiation through funding and project approval.

In accordance with the guidelines, an ASDP consists of the eight major sections summarized below:

1. **Need**. Outline the need for automation. Define the scope of the project. Summarize the functional requirements, including local area network (LAN) and multimedia (i.e., CD-ROM players and production, scanners, electronic classroom components) requirements. Describe the current method and evaluate the operational impact of maintaining the status quo.

2. **Proposed Solution**. Provide detailed configuration information. Discuss special requirements, such as data communications, multimedia, user training, site preparation, LAN installation and administration. Identify assumptions and constraints considered in the selection. Indicate milestone schedule of planned events.

3. **Other Alternatives Considered**. Summarize the alternatives not selected and explain the shortcomings based on technical and/or operational feasibility, and/or cost effectiveness.

4. **Costs and Benefits**. Summarize the projected costs for non-recurring acquisition and recurring life cycle operations. Identify the expected benefits, including increased productivity, improvements in function, cost avoidance, and cost savings/offsets.

5. **Interface Considerations**. Describe existing, planned or potential interfaces with systems/procedures external and internal to the organization.

6. **Testing**. Describe the applicable developmental and operational tests to be conducted prior to implementation.

7. **Funding**. Identify funding types, sources, and availability.

8. **Other Comments**. Address additional requirements and considerations, such as user training, security, site preparation, system administration, hardware/software maintenance.

The requirements to document life cycle support issues, planning considerations, costs and benefits in an ASDP are applicable to the development of a methodology to analyze the costs and potential benefits of converting conventional courses or computer-based training to the IETM/AC technology. As part of that analysis, a variety of factors that impact both the costs and the benefits should be examined. These factors include the characteristics of the course, the current

requirements for course management versus the requirements for the new technology, the interface with and support of the schoolhouse infrastructure, as well as the alternative hardware and software capabilities for authoring and delivering the IETM/AC instruction.

2.3 Methodology

Figure 2 provides an overview of the process used to analyze the costs and benefits of implementing the IETM/AC technology. The process is organized into seven major activities. The relationship between each of the activities and the relevant sections of an ASDP is illustrated in the figure. Although the activities appear discrete, they are interdependent and somewhat concurrent as indicated by the multiple references to sections in an ASDP. The following paragraphs briefly summarize the activities and the inputs to an ASDP. A detailed description of each of these activities is provided in the Section 3.

The initial step in the process should be an analysis of the course characteristics. The potential benefits to be gained by automating the course should be examined to determine if the course is a good candidate for conversion. If the analysis indicates yes, then the results should be useful in preparing the statement of the need (Section 1 of an ASDP) and a preliminary definition of the benefits (Section 4 of an ASDP).

If the potential benefits suggest that a course should be selected for conversion, then an analysis of the requirements for managing the course with the new technology versus the status quo should be conducted. The analysis should consider trade-offs in personnel time, personnel requirements, facilities, distribution costs, as well as other considerations. As shown in Figure 2, the analysis of course management requirements should provide inputs for preparing the statement of the need (Section 1 of an ASDP), a preliminary set of requirements for the proposed solution (Section 2 of an ASDP), and a statement of other special requirements (Section 8 of an ASDP).

If the trade-offs in course management requirements indicate that the course should be converted, then an analysis of the requirements and costs associated with course conversion should be conducted. This analysis should focus on redesigning the course to take advantage of the enhanced instructional capabilities of the IETM/AC technology. The capabilities required for authoring and multimedia development and support should be explored in terms of personnel resources and costs. The results of this analysis should provide inputs for preparing the statement of the proposed solution (Section 2 of an ASDP), the summary of costs (Section 4 of an ASDP), and description of the interface requirements (Section 5 of an ASDP).

The analysis of delivery system capabilities should include instructor and student station hardware and software configurations, other automated classroom components, networking requirements, and classroom furniture. The capabilities of different configurations and various options should be explored thoroughly and the costs should be compared to identify the most cost effective solution. As indicated in Figure 2, the results of the analysis should be used in preparing a detailed statement of the proposed solution (Section 2 of an ASDP) and a discussion of the other alternatives that were investigated (Section 3 of an ASDP).

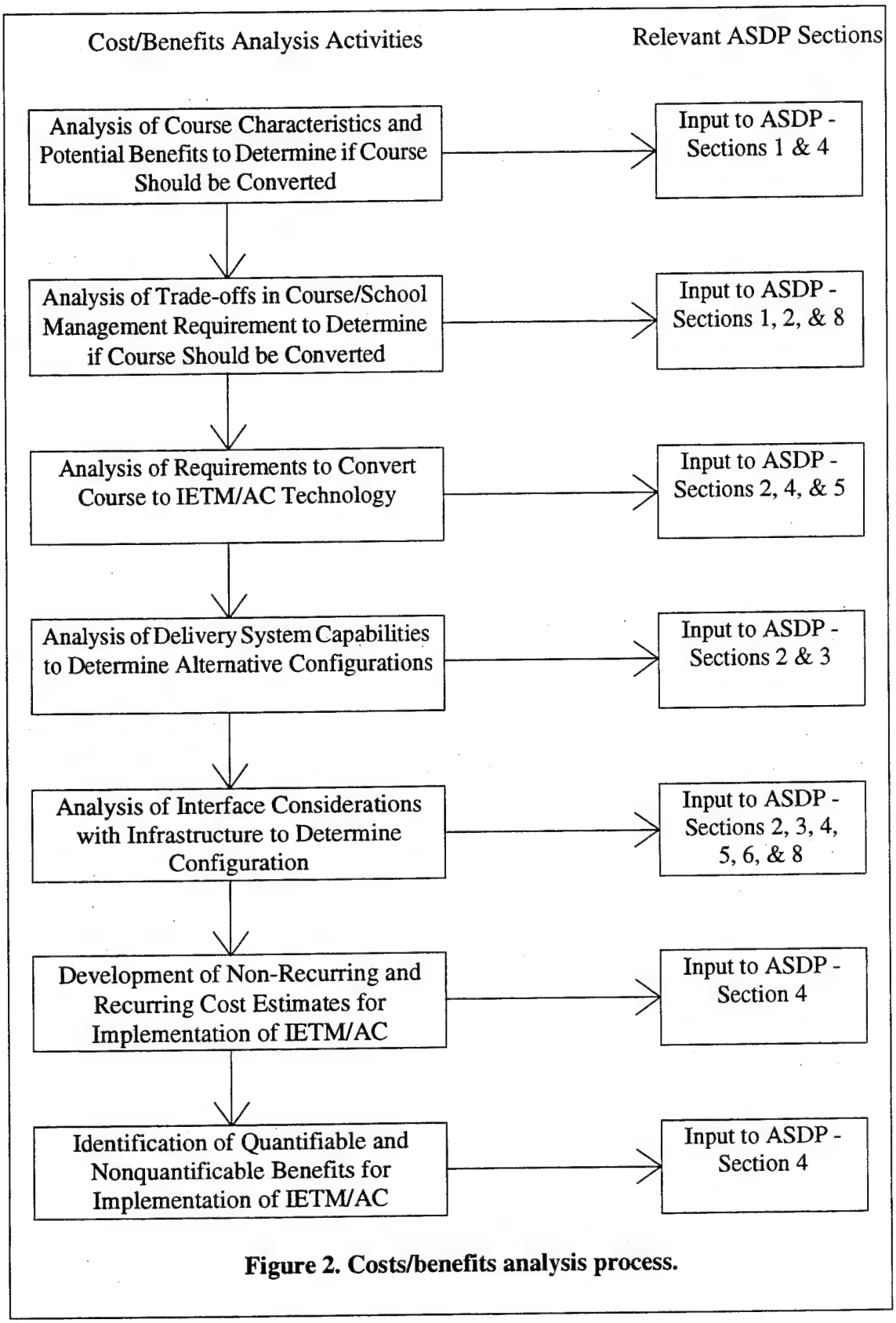

Figure 2. Costs/benefits analysis process.

After the previous activities have been accomplished, an analysis of the interfaces with the schoolhouse infrastructure should be conducted to determine configuration and support requirements. The analysis should consider factors such as site preparation, special facilities requirements, communications, networking, multimedia development capabilities, CD-ROM mastering and production, software inventory and licensing control, customized software support, hardware maintenance support, life cycle support, as well as IETM database maintenance functions. The results of the analysis should provide inputs for preparing the statement of the proposed solution (Section 2 of an ASDP), a discussion of the alternative configurations considered (Section 3 of an ASDP), the summary of costs (Section 4 of an ASDP), a description of the interface requirements (Section 5 of an ASDP), a plan for testing (Section 6 of an ASDP), and a statement of other special requirements (Section 8 of an ASDP).

Non-recurring (one time) and recurring (annual) cost estimates should be developed for the proposed solution and any other alternatives that are considered feasible. As shown in Figure 2, the results of this activity should be the summary of projected costs (Section 4 of an ASDP).

The potential benefits that were identified during the initial analysis should be evaluated further. These benefits should be quantified, where possible, to provide justification for the proposed solution. The results of this activity should be the statement of benefits (Section 4 of an ASDP).

Section Three

Costs/Benefits Analysis Process

3.0 Costs/Benefits Analysis Process

3.1 Overview

The process used to analyze the costs and benefits of implementing the IETM/AC technology in NAVEDTRACOM schools was summarized in Section 2.3. Each of the seven activities listed below is described in detail in this section.

1. An analysis of the course characteristics and the potential benefits to determine if the course should be converted.

2. An analysis of the trade-offs in course/school management requirements to determine if the course should be converted.

3. An analysis of the requirements to convert the course to the IETM/AC technology.

4. An analysis of delivery system capabilities to determine alternative configurations.

5. An analysis of the interface considerations with the infrastructure to determine the configuration and support requirements.

6. The development of non-recurring and recurring cost estimates.

7. The identification of quantifiable and nonquantifiable benefits.

3.2 Analysis of Course Characteristics

The characteristics of a course or courses within a school need to be analyzed to determine the potential benefits that may be realized by introducing the IETM/AC technology. The analysis of course characteristics may encompass conventional paper-based group-paced instruction as well as computer-based self-paced instruction that could benefit from incorporation of an IETM database or automated classroom components. Implementing several courses may be an important consideration in achieving cost savings and other efficiencies.

Table 1 is designed to provide a framework for the analysis. In the left-hand column of the table, the course characteristics are organized into broad categories with relevant questions posed for each category. In the right-hand column, potential benefits that relate to the questions are stated. The categories, questions, and benefits in Table 1 are representative of the issues that need to be addressed. They are not meant to be comprehensive since any given course may have unique characteristics that impact the benefits.

As defined in the table, the first two characteristics in the analysis of potential benefits deal with how the course(s) fit into the training pipeline and what student throughput is projected.

Table 1

Analysis of Course Characteristics and Potential Benefits

Course Characteristics	Potential Benefits
Training Pipeline and Course Length Where is the course taught in the training pipeline? Is this a core course that feeds several strands in the training pipeline? Can the training pipeline be shortened? Can the content be included in another course to reduce overall training time? Can the use of IETM/AC technology reduce the length of the course? With IETMs in use in the fleet, can proceduralized portions of the course be designed as just-in-time training or job performance aids?	**Reduced Student Training Costs** By eliminating a course or reducing the length of a course it may be possible to shorten the overall training pipeline. A reduction in training time translates to student cost savings. A reduction in training time may also translate to student TDY cost savings. IETM-based just-in-time training or job performance aids may enhance fleet operational capability, while reducing formal school training time and costs.
Student Throughput What is the student throughput? Is the throughput projected to increase or decrease in the future? Are there plans to combine related technician ratings?	**Lower Cost per Student per Course** The higher the student throughput, the lower the cost per student per course.
Academic Attrition/Setback Rate What is the academic attrition/setback rate? How much mandatory study time is required?	**Reduced Student Training Costs** The IETM/AC technology may reduce academic attrition, thereby avoiding student training costs.
Student Proficiency Are student performance scores adequate? Can the scores be improved? Is more proficiency required in the fleet?	**Improved Student Performance Scores** The technology may improve student performance scores and increase proficiency, while reducing student training time.
Format of Course Materials What percentage of the materials are in electronic format? What percentage are in paper format only?	**Reduced Development and Revision Time** Electronic formats reduce the time to develop, store, distribute, and revise training materials.
Stability of Course Content How often does the technical content of the course change? How significant are the revisions? How important is it to have current, accurate training? Does the course use the technical manuals/documentation that is revised frequently? How time-consuming is it to revise the IG, TG, and tests? Are information sheets included in the TGs along with assignment sheets? How long does it take instructors to personalize the revised IG?	**Reduced Revision Time** If the technical course content must be changed regularly to present current, accurate information, then the course should be developed in electronic format. It requires less time to revise IGs, TGs, tests, and other supporting instructional materials in electronic format. Dissemination of up-to-date technical documentation on CD-ROM significantly reduces revision time. **Reduced Instructor Personalization Time** After course revision, instructor personalization time is reduced by making annotations in an electronic IG.

Table 1 (Continued)

Course Characteristics	Potential Benefits
Course Graphics/Visuals Are graphics/visuals an important aspect of the course? How many graphics/visuals are used in the course? Are more graphics/visuals needed? What quality are the graphics/visuals? Are they paper-based or in electronic format? Does the instructor or a graphics artist develop the visuals? Is a word processing draw package used? Does the course present concepts that are difficult to grasp using traditional media and graphics? For example, can animations illustrate concepts more effectively?	**Reduced Development and Revision Time** Depending on the complexity of the visuals, creating digitized graphics may increase or decrease the initial development time, but the revision time can be significantly reduced. Scanning paper-based graphics may result in degradation of image and usability, especially if the print quality is poor or the graphic is a fold-out. **Improved Student Performance Scores** After course revision, instructor personalization time is reduced by making annotations in an electronic IG.
Course Media/Materials What media/material are used in the course? Is it lecture-based with chalk talk? Are wall charts, transparencies, slides, audio/visual aids, mock-ups being used? Is the course structured to include both classroom and laboratory sessions? What kind of lab sessions are conducted? How much time is spent in the lab? Can lab exercises be simulated in the classroom to alleviate bottlenecks in the lab? Are technical manuals used in the classroom and/or lab? Has an IETM database already been developed? Can other media be introduced, such as interactive courseware (ICW) to facilitate learning? Can portions of the course be self-paced rather than group-paced instruction? Can students work together in groups?	**Reduced Development and Revision Time** By eliminating a course or reducing the length of a course it may be possible to shorten the **Reduced Management/Distribution Costs** Electronic format reduces the costs for course supplies, media/materials inventory and storage space, reproduction services, training materials distribution, IETMs facilitate the use of up-to-date, current technical manuals in the classroom. **Improved Student Performance Scores** The technology may facilitate student learning and increase proficiency.

The next two characteristics in Table 1 address student performance and proficiency. The last four characteristics focus on course design, format, content, and media/materials.

The most significant benefits to be realized are reductions in student training costs. This is particularly true if these reductions are accompanied by better trained personnel returning to the fleet in a shorter period of time. Another important benefit is an increase in student proficiency that translates to improved operational readiness. One consideration for implementing the IETM/AC technology in the schoolhouse may be not only to train technicians to perform operation and maintenance tasks, but to also provide training on how to use the IETMs that are being introduced into the fleet. Other potential benefits for introducing the new technology may be the capability to deliver more up-to-date, technically accurate, and effective instruction in conjunction with reductions in course development, management, distribution, and revision time.

The results of this analysis provide inputs for preparing an ASDP. Examining the course characteristics and identifying potential benefits helps establish the need for automating the course (Section 1) and provides a preliminary statement of the benefits (Section 4).

3.3 Analysis of Trade-offs in Course Management Requirements

The analysis of the requirements to manage paper-based courses versus IETM/AC-based courses is a complex undertaking that should be addressed at the school level. Implementation of the new technology in just one course in one classroom in a schoolhouse can have consequences that extend beyond that classroom. For the most part, the management requirements for the two alternatives are very different and have implications for: (1) the organization and its structure, policies, and procedures; (2) the instructors and their duties; (3) the roles and responsibilities of management, administrative, and support personnel; (4) the facilities and their utilization; and (5) funding for life cycle support of the automated classroom components. If the status quo includes management of computer-based training in a classroom setting, then the analysis will only need to take into account additions and/or modifications in requirements as a result of the new technology.

The analysis must look at the trade-offs between the alternatives to determine if the potential benefits identified are offset by the changes in management requirements. In some cases, the changes in management requirements may simplify procedures, reduce time and effort, or make more efficient use of facility space. In other cases, the changes may add a number of new functions to be performed and requirements to be supported, require personnel training for new skills, dictate a different mix of personnel, or increase time and effort. All of these changes have cost implications that must be addressed as part of the decision making and planning process. With the rapid evolution in technologies and advances in system capabilities, the analysis of management requirements should be viewed as an ongoing process both during and after implementation.

This analysis results in inputs for preparing an ASDP. The evaluation of the requirements for managing the status quo course(s) versus the converted course(s) should provide clarification of the need to implement the IETM/AC technology (Section 1). The analysis of trade-offs should help define the best approach (Section 2) and identify additional requirements that must be addressed (Section 8).

Table 2 is designed to assist school personnel in conducting the analysis. The left-hand column of the table provides general definitions of course management requirements. There may be other requirements and considerations for any given course. The list of general requirements is meant to be representative and serve as guidelines for specific applications. The center column describes the implications for meeting that requirement in a traditional paper-based course, while the right-hand column summarizes the implications in an IETM/AC-based course.

The first four requirements in Table 2 relate to instructors and their roles in and out of the classroom. Implementation of the new technology has a profound effect on the duties that the instructors perform and the skills that instructors require. One of the key requirements is to provide training on how to use the technology to develop, personalize, and deliver instruction. Although some members of the instructional staff may be computer literate, some type of formal instructor training is necessary to bring all of the staff up to at least a minimum level of competency and reduce the learning curve time. The formal instructor training needs to include such features as hardware/software setup and operations, techniques for training students to use the system, making annotations to personalize the instruction, developing on-line training aids using computer-based graphics software, using the system capabilities for monitoring student activities, controlling classroom activities and time, and performing automated testing functions.

The next two requirements in the table relate to classroom facilities and scheduling. The trade-offs here are dependent upon the adequacy and availability of classrooms in the schoolhouse. The implementation of the IETM/AC technology may require extensive classroom refurbishment and costly preparation. However, these costs can be offset if several courses can share the classroom. Scheduling several courses in an automated classroom may require changes in shifts, create problems of shared access, and introduce security issues.

The requirements to maintain, reproduce, and distribute course materials in Table 2 are interrelated. These trade-offs in course management requirements favor using the new technology. For the most part, having materials in electronic format simplifies the procedures, decreases the inventory space that is required, and reduces costs as well as personnel time. However, the advantages may be negated by the need to perform system administration functions for the automated classrooms that are not required in conventional classrooms. Two other requirements shown in the table, networking and system administration, go hand-in-hand. The decision to use a local area network (LAN) in the classroom has an impact on the system administration functions that need to be performed.

The requirement for personnel training is often overlooked when implementing new technology. In-house management and support personnel may require specialized training to handle the network and system administration requirements. The type and amount of training and the respective costs are a function of the mix of personnel skills and capabilities. Training may not be required, however, if the decision is made to use contractor support to perform LAN and system administration functions.

Table 2

Analysis of Course/Schoolhouse Management Requirements

Definition of Requirement	Paper-based Course	IETM/AC-based Course
Instructor Training Formal instructor training addresses course design, development, and implementation with emphasis on group-paced instructor-led training.	Instructors are subject matter experts who have been trained to design, develop, and deliver platform instruction with traditional instructional media/materials.	Instructors require training to use the technology for instructional development and classroom presentation. Approximately 40 hours of initial training, depending on the hardware and software, plus some follow-on sessions may be required.
Instructor Preparation The time an instructor spends preparing for classroom sessions may vary depending on the individual instructor's experience level and the stability/maturity of the course.	Delivering training with traditional instructional media/materials (such as paper-based IG and TGs, chalkboards, transparencies, tech manuals requires a minimal amount of instructor preparation time.	Use of the new technology requires an extensive amount of instructor preparation time and new tasks like checking set up of the student and instructor stations. As instructors get up on the learning curve, this time should decrease.
Instructor Personalization Individual instructors make personal annotations in the Related Instructional Activity (RIA) column in IG	Depending on course complexity, frequency of revisions, and instructor's experience with content, instructor personalization may be a time-consuming activity.	Capability for instructors to make a standard set of annotations for new or revised courses, share personal annotations on-line, use annotations to link/launch to other media objects such as IETMs.
Instructor Classroom Management Instructors deliver instruction, manage classroom time, interact with students, monitor student progress, administer tests and remediation.	Delivering training with paper-based IG, Tgs, and technical manuals can make it difficult for an instructor to monitor individual student progress. Instructors must interact with students by asking questions to determine their progress. Classroom time may be wasted.	Use of the new technology allows the instructor to control the presentation and monitor the class or individual student progress simultaneously. Use of classroom time is more efficient with on-line rather than paper-based training materials and technical manuals.
Classroom Facilities The physical classroom space including furniture, training media devices, equipment, utilities, etc. The availability and adequacy of classroom facilities varies from school to school.	Classroom facilities for a paper-based course with conventional instructional media/material may be used for a number of courses or for a limited number of courses if specific equipment or extensive sets of technical manuals/documentation is required. Classroom facilities do not require special electrical wiring, air conditioning, flooring, etc.	Classroom facilities for an IETM/ AC-based course may be used for a number of courses. The only requirement is to have the appropriate course materials available on the instructor and student stations. Classroom facilities require electrical wiring, cabling, air conditioning, flooring, etc. to support the hardware.

Table 2 (Continued)

Definition of Requirement	Paper-based Course	IETM/AC-based Course
Classroom Scheduling Classroom scheduling is a function of the student throughput, course convene dates, and the availability and adequacy of classroom facilities.	Generic classroom facilities simplify course scheduling. During peak loads, scheduling classrooms designed for specific courses may be difficult and require extra shifts.	Scheduling is a major concern for IETM/AC facilities. When the number of classrooms is limited, scheduling must consider multiple classes as well as study time. The appropriate course materials must be accessible at the correct time.
Course Inventory An inventory of all of the media/ materials required to present a course must be maintained in a secure space. These items include course consumables, media delivery devices and spare components, multiple sets of technical manuals, training aids, instructional materials and tests.	For traditional paper-based courses, an adequate inventory of course consumable items, media delivery device components (i.e., overhead projectors), training aids, training materials (IGs, TGs, tests), and sets of technical manuals for students to use in class must be maintained.	For IETM/AC-based courses, most of the items in the course inventory are stored in electronic format (i.e., CD-ROM, hard disks, or floppy disks). An inventory of consumables and media delivery device components (i.e., spare mouse, light bulbs, headphones) is still required, but the facility space is significantly reduced.
Course Reproduction Costs The costs for reproducing the course training materials, including the IGs, TGs, tests, training aids, other training/reference materials, and sets of technical manuals.	The lead time and the costs for reproducing multiple copies of paper-based course materials and transparencies/slides at the base printing ship/support office may be significant depending on the course content and structure.	The costs as well as the time required to generate multiple copies of course materials in electronic format is significantly reduced.
Course Distribution Procedures for establishing accountability and maintaining security in the distribution of instructional materials and tests for each course convene.	The effort to distribute the needed paper copies of instructional materials and tests may be significant, especially if each student requires a set of technical manuals. Instructors are responsible for security of the materials.	The effort to distribute the necessary instructional materials and tests in electronic format is significantly reduced. However, the problems with establishing accountability and maintaining security are increased.
Networking Use of a local area network (LAN) to establish a client/server relationship between the instructor and student stations in a classroom.	As defined, networking is not a feature of a traditional paper-based course.	In most cases, networking is an important aspect of efficiently managing IETM/AC courses. A trained LAN administrator is required to support the implementation.

Table 2 (Continued)

Definition of Requirement	Paper-based Course	IETM/AC-based Course
System Administration Functions include, but are not limited to, providing assistance to instructor and staff, managing software inventory, establishing configuration control, performing backups, performing preventative maintenance and diagnostics, interfacing with vendors and support activities, establishing procedures and policies.	As defined, system administration functions are not necessary for managing paper-based courses.	System administration functions are essential for managing IETM/AC-based courses. The number of administrators required depends on the capabilities of the personnel, the number of student and instructor stations, the number of courses, the complexity of the configuration, the use of networks, security issues, the types of support that are available in-house or by contractors.
Personnel Training Course management and support personnel may require specific training to perform their functions.	For traditional paper-based courses, no training or minimal training may be required. For the most part, no specialized skills or knowledge are necessary.	The system administration functions introduced by the ITEM/ AC technology require specialized training for management and support personnel.
Performance Testing Student testing during the course and performance assessment at the end of the course.	For traditional paper-based courses, the Instructional Support System/ Micro Standing Training Activity Support System (ISS/MicroSTASS) requires hand scanning of multiple choice answer sheets for exams. Analysis and reporting is performed at central location.	The Audience Tailored Instructional Testing Environment (ATITE) allows on-site rapid analysis of student scores immediately after tests. On-line testing reduces paper requirements and allows instructors to generate any number of random tests from test item database.
Remediation and Study Instructors need to diagnose student problems and prescribe remediation activities and outside study.	For traditional paper-based courses, students can study classroom notes and complete remediation activities anytime and anywhere.	For IETM-based courses, students must have access to the IETM systems. This adds to demands on classroom time, unless separate study/remediation systems are made available to students.

The implications for testing and remediation should also be considered. Automated performance assessment and record keeping software may provide instructors with a variety of features that are not available in paper-based testing. However, to achieve maximum effectiveness and efficiency, these features need to be integrated with the schoolhouse performance reporting requirements. Automated performance assessment software may also allow instructors to diagnose specific remediation activities for students having problems. But, scheduling remedial training sessions needs to consider constraints on automated classroom resources.

3.4 Analysis of Course Conversion Requirements

The introduction of IETM/AC technology offers new vistas for instructional development and delivery. The capability to present instruction using interactive graphics, animations, and immediate access to up-to-date technical information provides new design possibilities. Most, if not all, paper-based courses that are converted to include an on-line IETM database should be redesigned to take advantage of the enhanced capabilities that are available. Just presenting IETM references electronically in the classroom rather than physically searching the technical manuals is not utilizing the technology to its fullest extent.

In current practice, the process of developing an IETM to be used in training and in the fleet is separate from the process of developing instructional materials for use in the formal school. A discussion of the options and processes for authoring IETMs and the relationship of the processes to authoring instructional materials is beyond the scope of this study. However, they are discussed in detail in a survey of IETM practices in military, commercial and higher education applications that was conducted under contract to NRPDC (Kribs & Mark, 1995).

Whether training materials are going to be integrated with the IETM database and how the IETM elements are going to be launched in the training materials will impact the course conversion effort. The requirements for converting the course should be based on an analysis of the links between the training materials and the electronic technical documentation and the tools and processes to accomplish these links.

The number of technical manuals to be included in the IETM database as well as the accuracy, readability, and legibility of their content will also be a factor in the course conversion effort. For a mature operational system, the quality of the legacy data that is scanned or digitized into electronic format may not be adequate for classroom presentation. Fold-out schematics that have been converted as separate pages in an electronic format or detailed illustrations that have been raster scanned may not be of sufficient resolution and clarity for use as training media in an automated classroom.

3.4.1 Conversion Process

There are two sets of procedures for developing and revising curriculum in the Navy. The Personnel Performance Profiles (PPP) based procedures are documented in the NAVEDTRA 131 training manual series and the task based procedures are documented in the NAVEDTRA 130 training manual series. The process for converting a traditional course to the IETM/AC format should follow the guidelines for revising an existing course that are documented in the appropriate training manual series.

The introduction of the IETM/AC technology may result in changes in the learning objectives and the instructional sequence in both PPP-based and task-based courses. It may also result in changes in student testing and performance assessment techniques. For example, paper-based short answer tests may be replaced by on-line multiple choice test questions randomly selected from a test item pool. The capabilities of performance assessment and management software packages to provide on-line testing and reduce administrative record keeping tasks should be investigated for use in the automated classroom.

The IETM/AC format will impact the Resource Requirements List developed for both types of courses. A survey of commercial-off-the-shelf (COTS) software should be conducted to see what capabilities are available at what cost as part of developing the Resource Requirements List for the revised course. Any number of COTS packages may provide inexpensive, easy-to-use features to augment deficiencies in the visuals in the IETM database and enhance the effectiveness of the instruction.

As mentioned earlier, the Navy's AIM (Authoring Instructional Materials) software is used to author PPP-based lesson plans and trainee guides, while standard word processing software (Word Perfect) is currently used to author task-based lesson plans and trainee guides. Regardless of the software used to convert the course to the IETM/AC format, there must be a capability to link and launch to other media including IETMs, interactive courseware (ICW), video, audio, animations, and graphics.

The format neutral architecture provided by the Training Integration Management Software (TIMS) should enhance the capability to integrate instructional materials from all Windows-based sources into the IETM/AC format. There is also an ongoing effort by the Naval Aviation Warfare Center/Training Systems Division (NAWC/TSD) to revise AIM to operate in a Windows-based environment and to allow authoring of both task-based as well as PPP-based instructional materials. The impact of these new versions of AIM as well as advances in electronic publishing technology for SGML and HTML (Hypertext Markup Language) need to be monitored.

The following types of questions concerning instructional development support should be asked as part of the conversion process:

- Is there an organization that provides authoring support using AIM or conventional word processing software? How are requirements integrated?
- What COTS software is required to support the redesign of the instructional materials?
- Are there requirements for COTS or customized applications software (i.e., performance assessment and management)?
- Is there an organization that provides in-house or contractor support developing computer-based training materials in the form of ICW, animations, enhanced graphics and visuals? How are requirements integrated? What are the costs?
- Are there requirements for the Visual Information Support Center to provide support?

- Are there requirements for specialized hardware or services (i.e., conversion to vector graphics)? If so, what are the costs?

3.4.2 Cost Estimating Parameters

A standard metric for converting conventional courses to an IETM/AC format, like the metric used to estimate the costs for developing computer-based training (i.e., 200 labor hours per hour of instruction), cannot be developed until more experience is gained. The parameters for estimating conversion costs must rely on conventional cost estimating techniques for revising an existing course. That is, the personnel costs for performing the necessary analysis, design, and lesson development activities, including linking and launching to media objects, must be estimated. The costs for instructional media (i.e., graphics, animations, ICW, audio, video) development to take advantage of the automated classroom capabilities and enhance the effectiveness of the instruction must also be estimated. Depending on the organization, the developers may be instructors, in-house staff, contractor personnel or a combination of the above.

The results of the analysis of course conversion requirements provides inputs into preparing the statement of the proposed alternative (Section 2 of the ASDP), the summary of costs (Section 4 of the ASDP), and the description of interface considerations (Section 5 of the ASDP).

3.5 Analysis of Delivery System Capabilities

The analysis of delivery system capabilities includes the hardware and software configuration for the instructor station, the student stations, the classroom furniture, other automated classroom components, and the local area network components. The purpose of the analysis is to evaluate alternative delivery system configurations in terms of costs and capabilities. This analysis is directly relevant to the preparation of an ASDP. The analysis should result in a statement of the best system configuration (Section 2 of the ASDP) and a description of the alternative configurations that were considered (Section 3 of the ASDP).

The current IETM/AC configuration includes a LiveBoard (an electronic blackboard) for classroom presentations and a computer-controlled LINK video networking system to allow the instructors to control the student station displays. An analysis of the course requirements should be conducted to determine if these delivery system components are necessary and, if so, what features they should provide.

The instructor station requirements should specify the CPU configuration including memory, speed, sound card, modem, a CD-ROM player, tape backup, operating system, COTS software, customized applications software, input devices, size of monitor, miscellaneous peripherals such as printers and surge suppressors. In determining these specifications, it is essential to decide whether the IETMs will be stored and executed from the CD-ROM player or from the hard drive.

The network requirements should specify the hardware and software configuration (instructor station system or separate file server system) including the LAN operating system, file

server capacity, number and location of users, application software, processing requirements, wiring/installation, and communication interfaces.

The specification for the student stations should be based on the specifications for the instructor station and network. The student station requirements should specify the CPU configuration including memory, speed, sound cards, a CD-ROM player, operating system, input device and COTS run time software.

The specifications for the delivery system should also include the necessary classroom furniture to support the configuration. Furniture includes the type and number of student work stations, the type of instructor station, an instructor podium, chairs, stools, tables, printer stands, and portable units for use in laboratories or other classrooms. The costs for alternative features should be analyzed to determine the best value to meet the requirements.

3.6 Analysis of Interface Considerations

When a course is converted to IETM/AC technology, it may have an impact on systems, procedures, and organizations that are both internal and external to the schoolhouse. For the most part, the impact within the schoolhouse is discussed above in the analysis of course management requirements. Additional interface considerations within the schoolhouse may include such things as networking several classrooms to a central file server system to distribute training.

The impact of the IETM/AC technology on the interfaces with infrastructure outside the schoolhouse should also be considered. The infrastructure will vary from one organization to the next and so will the interface issues. To facilitate the analysis, the concerns that need to be addressed have been organized into general categories. A representative set of questions is provided below for each category.

3.6.1 Facilities

- What classroom space is available? What kind of site preparation and refurbishment is required to support the hardware/software configuration?
- Are there command or base contracts available to obtain contractor support for site preparation, classroom refurbishment, equipment installation, cabling, etc.?
- What provisions are there for classroom facility maintenance (i.e., air conditioning service, filters, cabling)?
- Are there requirements for integration with the Learning Resource Center (LRC)?

3.6.2 Testing and Security

- What kind of testing procedures need to be established to verify system operations and reliability? Who should participate? When should it be done?
- What kind of physical classroom security procedures need to be established?

- What kind of ADP security procedures need to be established?
- Is classified material involved?

3.6.3 Hardware/Equipment Acquisition and Maintenance

- What procedures are established for acquiring both customized and COTS hardware?
- Can the small multi-user computer contract be used for COTS components? What Contract Line Item Numbers (CLINs) meet the requirements?
- Are other command or base contracts available for quantity buys?
- Can some items (i.e., computer workstations and chairs) be purchased through a GSA contract?
- Are other Navy contracts available to acquire specific hardware/equipment used in the automated classrooms? If so, what are the procedures for using them? How do requirements get integrated?
- Does the computer hardware come with a warranty? If so, how long?
- Does the vendor offer a maintenance agreement (i.e., on-call service, field support, repair and replace)? Are hourly rates charged?
- Is there a command or base ADP group responsible for preventive and/or corrective maintenance for microcomputers and peripherals?
- Should the acquisition include provisioning for spares for certain components to minimize downtime? If so, what components?

3.6.4 Networking

- What communications components are required?
- Are there specific LAN related interface and gateway requirements?
- Is a wide area network (WAN) available?
- Is connection to a host processor at a central site available or desirable?

3.6.5 Software Acquisition and Upgrades

- What procedures are established for acquiring both customized and COTS software?
- Can the small multi-user computer contract be used for COTS software packages? What Contract Line Item Numbers (CLINs) meet the requirements?
- Are other command or base contracts available for quantity buys?

- Are software site licenses available? Have they already been acquired at a command or base level? Who is responsible for managing software licenses?
- What procedures are established for software upgrades?
- Are other Navy contracts available to develop customized software? If so, what are the procedures for using them? How do requirements get integrated?
- Is there customized software that needs to be maintained and revised as requirements change?

3.6.6 Personnel Training/Logistic Support

- What procedures are established for acquiring the necessary personnel skill training (i.e., ADP administration, LAN administration, applications software)?
- Does the capability to provide systems administration and LAN administration support already reside on base? Can the school requirements be integrated?
- Are other command or base contracts available to provide contractor support for systems administration and LAN administration?
- Is there a contractor or Navy activity responsible for maintaining the IETM database? What are the procedures and schedule for receiving revisions in the schoolhouse?
- Do the requirements for the interface with the Technical Library change?
- Do the requirements for the interface with the Learning Resource Center (LRC) change?
- Is there a contract available for CD-ROM mastery and production? If so, what are the costs? How are requirements integrated?

This analysis should be conducted to ensure cost effective implementation and life cycle support of the IETM/AC technology in the schoolhouse. The results of the analysis of interface considerations are directly relevant to preparing a number of sections in an ASDP. The interface options and requirements impact the determination of the best approach (Section 2), the description of the alternatives that were considered (Section 3), the development of cost estimates (Section 4), the statement of the system interfaces (Section 5), the plan for testing (Section 6), and the definition of additional requirements (Section 8).

3.7 Development of Non-Recurring and Recurring Cost Estimates

The guidelines for preparing an ASDP call for the non-recurring (one time) and the recurring (annual) cost estimates to be presented in a summary format. The costs for the proposed solution are displayed first and then the costs for alternative solutions (if they were evaluated on the basis of cost) are displayed using the same cost elements to facilitate comparison. The scope and complexity of the project determine the cost elements and format to use. Generally, life cycle

costs, cost avoidance amounts, and return on investment figures are expressed in current fiscal year dollars. However, a present value analysis may be used to display the costs over the system life cycle.

Although the ASDP guidelines require only a summary display of major cost elements, an underlying life cycle cost model (LCCM) that documents the results of the analyses described in Sections 3.2 through 3.6 should be used to derive the summary costs that are presented. As part of this study, we developed a generic LCCM for analyzing the costs for implementing IETM/AC technology in other NAVEDTRACOM schools. The generic LCCM was designed using LOTUS 1.2.3, Release 4 for Windows, but any other spreadsheet software could be used. The use of spreadsheet software makes it relatively easy to refine the structure of critical cost elements and revise the cost data presented. It also highlights the relationships between cost elements and allows the impact of changes in cost estimates (i.e., minimum-maximum ranges) to be evaluated.

The generic LCCM is organized into two parts: non-recurring and recurring costs. For the purpose of this study, non-recurring costs are defined as the one time costs projected for initial acquisition and implementation of the IETM/AC technology in the schoolhouse. The LCCM for non-recurring costs is shown in Table 3. Recurring costs are defined as the annual life cycle management costs for operating and maintaining the technology. The LCCM for recurring costs is shown in Table 4.

The cost elements used in this study are broad in scope to meet the diverse requirements of future implementations. They consist of a number of sub-elements to help clarify the results of the costs/benefits analyses described previously. The following subsections define the non-recurring and recurring costs elements displayed in the generic LCCM shown in Tables 3 and 4, respectively.

Table 3

Life Cycle Cost Model: Non-Recurring Costs

Non-Recurring Cost Elements	Configuration 1			Configuration 2		
	Unit Cost	Quantity	Total Cost	Unit Cost	Quantity	Total Cost
Student Station						
Hardware/Software						
Work Station Furniture						
Instructor Station						
Hardware/Software						
Work Station Furniture						
Local Area Network						
LiveBoard						
Link System						
Basic Configuration						
Optional Features						
Classroom Preparation						
Designs						
Computer Room Flooring						
Installation						
Hardware Installation						
User Training						
Course Conversion						
Total Non-Recurring Costs						

Table 4

Life Cycle Cost Model: Recurring Costs

Recurring Cost Elements	Configuration 1			Configuration 2		
	Unit Cost	Quantity	Total Cost	Unit Cost	Quantity	Total Cost
Hardware Maintenance						
Software Maintenance						
Hardware/Software Upgrades						
Logistical Support						
System/Network Administration						
User Training						
Course Revision						
Total Recurring Costs						

3.7.1 Non-Recurring Cost Elements

The non-recurring cost elements that are usually used to derive the costs for implementing a new computer-based training system also apply to the IETM/AC technology. Generally, the costs elements cover hardware and software acquisition, installation, and courseware development costs. For the IETM/AC technology, the acquisition costs include hardware, software, other automated classroom components, local area network (LAN) components, user documentation, spares, classroom furniture, and user training. Installation costs include classroom design and preparation, refurbishment of the facility space (if necessary), physical installation of the hardware and network components. Courseware development costs cover course conversion to the IETM/AC format.

To make the LCCM more useful in determining the costs for future automated classroom implementations, the estimates for non-recurring costs are aggregated into the cost elements defined below.

Student Station. The configuration of a student station may vary depending upon the characteristics of the training to be delivered. The number of student stations required in a given automated classroom may vary depending on student throughput, course convenes, classroom availability and other facility constraints. The sub-elements include:

- Computer Hardware Configuration.
- Software Configuration (including COTS and customized applications).
- Student Workstation and Chair.
- User Documentation (if separately priced).
- Spares Provisioning (as applicable).
- Installation (as applicable).

Instructor Station. The configuration of an instructor station may vary depending upon the characteristics of the training to be delivered and classroom facility constraints. The sub-elements include:

- Computer Hardware Configuration.
- Laser Printer.
- Software Configuration (including COTS and customized applications).
- Instructor Workstation and Chair or Stool.
- Instructor Podium.
- User Documentation (if separately priced).

- Spares Provisioning (as applicable).
- Installation (as applicable).

Automated Classroom Components. The components to be included in an automated classroom may vary depending upon the requirements for instructional delivery and management and any constraints on classroom facilities. The sub-elements include:

- LiveBoard (Electronic blackboard).
- LINK System (Computer-controlled video networking).
- Local Area Network (LAN).
- Other Components or Equipment.
- User Documentation (if separately priced).
- User Training (as available).
- Spares Provisioning (as applicable).
- Installation (as applicable).

Classroom Preparation. The costs to prepare a classroom are a function of the designated space at a given facility and the delivery system configuration to be installed. For example, minimal costs would be incurred in upgrading a computer-based training classroom to support the IETM/AC technology. Major costs would be incurred when a space requires complete refurbishment. Classroom preparation may include items such as facility design, demolition, electronic power service upgrades, electrical power conditioning (GFI), power backup units, lighting fixture upgrades, environmental and climate control systems (controls, cooling/heating equipment, vent ducting, weather seals, registers/diffusers, dust/dirt air scrubbers, anti-static conditioners), paint, cable wiring and connectors, and computer room flooring.

Hardware Installation. The costs to physically install the hardware, furniture, LAN, and other automated classroom components may be separate or they may be included in the cost elements shown above.

User Training. The requirements and costs for user training are a function of the automated classroom configuration. The sub-elements include:

- Instructor Training.
- Systems Administrator Training.
- LAN Administrator Training.
- Software Applications Training.

Course Conversion. The costs to convert the course are a function of the course characteristics, the amount of redesign, the authoring system capabilities, and the personnel resources available. The sub-elements include:

- IG and TG Revision.
- Instructional Media Development.

3.7.2 Recurring Cost Elements

Generally, the recurring cost elements used to derive annual life cycle support cost estimates for a computer-based training system apply to the IETM/AC technology. Relevant costs include hardware maintenance, hardware upgrades, customized software maintenance and enhancements, software upgrades, logistical support, system administration, network administration. user training, and courseware revision costs. To make the LCCM more useful in determining life cycle costs for future automated classroom implementations, the recurring costs are aggregated into the cost elements defined below.

Hardware Maintenance. This element refers to the costs for maintaining the hardware for the instructor station, student station, and other automated classroom components. One or several of the following sub-elements may apply:

- Hardware Warranty (part of the acquisition costs).
- On-Site or On-Call Field Service (by the vendor).
- Spares Provisioning (swap out components and return defects to vendor).
- Command ADP Service Center (in-house group responsible for corrective maintenance).

Software Maintenance and Enhancements. This element refers to the costs for maintaining and enhancing any customized software included in the classroom configuration.

Hardware/Software Upgrades. This element refers to the costs for upgrading COTS hardware components (i.e., Pentium processors, increased memory) and COTS software packages. As technology advances, both the hardware and software capabilities will increase and upgrades are an inexpensive way to keep pace.

Logistical Support. This element refers to the costs for maintaining training consumables and supplies; storing and reproducing training materials; updating, maintaining, reproducing, and distributing the technical manuals; pressing and replicating CD-ROMs; and special classroom requirements (i.e., air conditioning filters, light bulbs).

System/Network Administration. This element refers to the personnel costs for administering the IETM/AC classrooms and LANs. The mix and number of personnel are a function of the requirements at the schoolhouse.

User Training. This element refers to the on-going requirement for training as personnel change and the classroom configuration is upgraded. The sub-elements include:

- Instructor Training.
- Systems Administrator Training.
- LAN Administrator Training.
- Software Applications Training.

Course Revision. This element refers to the costs for revising the instruction (IGs, TGs, and other media) due to content deficiencies or changes in technical content, including updates to the IETM database.

3.8 Identification of Benefits

The final activity in the process of analyzing the costs and benefits of implementing the IETM/AC technology in NAVEDTRACOM schools is to identify both the quantifiable and the nonquantifiable benefits. The guidelines for preparing Section 4 of an ASDP suggest five benefit areas that may be relevant in justifying the proposed solution. These general benefit areas are defined as follows:

1. Cost avoidance--an increase in the operational efficiency of personnel by reducing the time spent performing specific functions.

2. Cost savings or cost offsets--direct reduction in operational costs and identification of specific areas that will be reduced or eliminated as a result of implementing the proposed solution.

3. Increased productivity--description of improvement, quantified in labor hours or workload.

4. Quality and accuracy--description of improvement, such as a reduction in error rate.

5. Manageability--description of improvement, such as a savings in the number of labor hours.

To augment these general benefit areas and assist in developing the statement of benefits, we offer the following list of benefits that may be realized by implementing the IETM/AC technology:

- Decrease in student training costs by reducing course length.
- Lower cost per student per course by increasing student throughput.
- Decrease in instructor class preparation time.
- Improvements in student performance scores.

- Reduction in student academic attrition and setbacks.
- Reduction in media development and/or revision time.
- Reduction in course management and distribution costs.
- Decrease in costs for course supplies/instructional media (i.e., avoid costs for paper, reproduction, inventory, and storage).

Section Four

Costs/Benefits Model

4.0 Cost Benefits Model

4.1 Scope

As documented in the Evaluation and Implementation Plan (EIP) for the joint project, NAVSEA was responsible for providing the funding and support to implement the IETM/AC technology in the GSE/GSM classrooms for field testing and evaluation. NPRDC was tasked to evaluate the effectiveness of potential enhancements to the technology and determine the efficiencies of the automated classroom. Based on the results of the evaluation, NPRDC and NAVSEA are responsible for developing specifications and recommendations for future implementations. CNET and NAVSEA are responsible for providing support to transition the products into the training environment. The costs/benefits model presented in this section was developed as part of the evaluation.

The costs/benefits model for the GS "C" School supports the format requirements for Section 4 of the ASDP (Costs and Benefits). The model has three components: (1) the statement of benefits, including both qualitative and quantitative benefits, (2) the LCCM for non-recurring costs described in Section 3.7.1, and (3) the LCCM for annual recurring costs described in Section 3.7.2.

As part of the analysis, we assigned confidence levels to the cost estimates developed for the costs/benefits model. The alphabetical designator and definition for the different levels of confidence (taken from OPNAV Instruction 7000.17A) are listed below.

A. Detailed Cost Estimate based on contract plans and evaluation of firm quotes for major material items.

B. Bid Evaluation Cost Estimate based on contract plans and evaluation of contractor proposals in response to an RFP.

C. Budget Quality Estimate based on engineering analysis of detailed characteristics of item under consideration.

D. Feasibility Estimate based on technical feasibility studies and/or extrapolated from higher quality cost estimates of similar items.

E. Computer Estimate based on cost estimating relationships and gross parameters.

F. Ball Park Estimates prepared in absence of minimum design and cost information and based on gross parameters.

The cost estimates developed for the quantifiable benefits were assigned a confidence level of "C" (Budget Quality Estimate) since they are based on student throughput projections and other assumptions. The cost estimates developed for the LCCM for non-recurring costs were assigned a confidence level of "A" (Detailed Cost Estimate) since they are based on costs provided by the Hardware Installation Activity responsible for acquiring the classroom hardware and software configuration.

We did not develop any cost estimates for the LCCM for recurring costs. As described in Section 5.1.1, several Navy organizations are in the process of specifying the life cycle management requirements for the automated classrooms. However, specific statements about the life cycle support requirements were not available and, in the absence of detailed information, we could not derive any meaningful annual recurring cost estimates. In light of the on-going efforts, the development of ball park estimates (a confidence level of "F") did not seemed warranted.

Section 4.2 presents the statement of benefits. The statement of benefits provides a comparison between converting the conventional paper-based courses to the IETM/AC technology and maintaining the status quo. Section 4.3 presents the non-recurring cost estimates to acquire and install the hardware and software configuration implemented in the five GSE/GSM automated classrooms. The non-recurring cost estimates are displayed in the LCCM format previously shown in Table 3. Section 4.4 provides general statements about the life cycle support requirements for the GSE/GSM automated classrooms. There are no recurring cost estimates to display in the LCCM format previously shown in Table 4.

4.2 Statement of Benefits

Both Section 3.8 and Section 5.2 discuss potential benefits that may be realized by implementing the IETM/AC technology in the schoolhouse. This section presents the immediate benefits that could be analyzed and quantified in a meaningful way of implementing the IETM/AC technology in the GSE/GSM courses. These benefits are summarized below:

1. **Improvements in student performance scores.** Initial data indicates a slight improvement in student performance scores in the IETM-based courses over student performance scores in the paper-based courses. These preliminary results suggest that the introduction of the IETM/AC technology and subsequent reduction in course length has not had an adverse effect on student performance.

2. **Reduction in student training costs.** The elimination of seven training weeks from the GSE pipeline and three training weeks from the GSM pipeline results in a reduction in student training costs of over $1,800,000 for FY 95 and FY 96. The assumptions used to develop these cost estimates were conservative to avoid overstating the potential benefits. The actual savings may be much larger than those stated here.

3. **Reduction in course reproduction costs.** The cost savings for not reproducing the paper-based technical manuals used in the GSE/GSM courses is estimated at over $96,000 for FY 96. Again, the assumptions used to develop this were conservative to avoid overstating the potential benefits. The actual savings may be much larger than those stated here.

In addition to these quantifiable benefits, there are other important benefits that impact the quality of the training. From the perspective of SSC GLAKES personnel, one of the most significant benefits of the IETM technology is the capability to have current, up-to-date technical manuals available for operational use in the fleet and for training in the classroom. The process of preparing and disseminating paper changes to users and having users incorporate the changes and maintain the paper-based manuals is time consuming, labor intensive and costly. Incorporating the IETM technology into the automated classrooms allows technicians attending the formal school to

receive technical training using the same accurate and current documentation available in the fleet. It also provides them with training on how to use the IETM technology when they are back on the job.

The benefits gained as a result of the GSE/GSM implementation relate directly to the initial decision to implement the IETM/AC technology in the GS "C" School. As discussed in Section 1.3.1, NAVSEA selected the gas turbine systems for development of an integrated IETM database for use aboard ship and in the schoolhouse for a variety of reasons. The logistic problems inherent in maintaining, updating, and distributing massive volumes of paper-based technical manuals made the gas turbine systems a prime candidate for automation. One consideration was to use advances in technology to improve the process of managing technical manuals and keeping technical information accurate and current for operational use in the fleet and in training.

A major consideration for selecting the GS "C" School as a field test site was the extensive use of large sets of technical manuals in the advanced GSE and GSM courses. The benefits to be gained by replacing paper materials with on-line electronically formatted materials appeared significant in terms of both the costs and personnel time required for to manage, store, distribute, and update the materials used in the classroom. Another consideration for introducing IETMs was the potential of reducing student training costs by reducing the length of the GSE and GSM courses. However, the question was whether the current levels of student proficiency could be maintained or improved with the reductions in course length.

Section 4.2.1 discusses the impact of the technology on student performance scores. Section 4.2.2 provides a detailed description of the reduction in student training costs estimated for the current fiscal year and projected for FY96. Section 4.2.3 presents the assumptions used in deriving the estimate of the savings in course reproduction costs for FY96.

4.2.1 Benefit: Improvements in Student Performance Scores

The comparison of student performance scores in the traditional paper-based courses and the IETM-based courses is still in process, but the preliminary results of the analysis look promising. The test scores for six paper-based GSE and GSM classes were obtained to use as the baseline. Test scores for seven GSE IETM-based classes and three GSM IETM-based classes were available for comparison at the time this report was prepared. The preliminary comparisons of GSE and GSM student performance scores are summarized in Tables 5 and 6, respectively.

As shown in Table 5, even though the number of students is small, there is a slight improvement (approximately three points out of 100) in the overall average student performance scores for the GSE IETM/AC classes. As shown in Table 6, with only three IETM/AC class graduations to date, there is also a slight improvement (approximately two points out of 100) in the overall average student performance scores for the GSM IETM/AC classes. These preliminary results suggest the introduction of the IETM/AC technology and subsequent reduction in course length has not had an adverse effect on student performance. The data for academic attrites and student setbacks was not sufficient to make any comparisons between the paper-based and IETM-based courses.

Table 5

Comparison of GSE Student Performance Scores

Paper-based Classes	Average Class Score	IETM/AC Classes	Average Class Score
93090 (N = 13)	87.32	94120 (N = 3)	94.77
93100 (N = 11)	92.55	94130 (N = 10)	93.32
94010 (N = 13)	90.23	94135 (N = 7)	91.09
94020 (N = 12)	89.43	95010 (N = 5)	85.60
94030 (N = 15)	84.49	95030 (N = 3)	95.30
94085 (N = 6)	90.03	95040 (N = 3)	94.30
		95045 (N = 2)	89.50
		95050 (N = 5)	In process
Number of Students	Overall Average Score	Number of Students	Overall Average Score
70	88.66	38	91.88

Table 6

Comparison of GSM Student Performance Scores

Paper-based Classes	Average Class Score	IETM/AC Classes	Average Class Score
94065 (N = 14)	89.01	95030 (N = 7)	93.90
94075 (N = 5)	93.72	95040 (N = 9)	88.60
94100 (N = 8)	89.74	95045 (N = 12)	95.80
94110 (N = 9)	89.82	95050 (N = 15)	In process
94120 (N = 7)	91.56	95060 (N = 6)	In process
94145 (N = 9)	92.54		
Number of Students	Overall Average Score	Number of Students	Overall Average Score
52	90.60	49	92.23

4.2.2 Benefit: Reduction in Student Training Costs

The potential savings in student training costs are a function of the average cost per student per week per course, the projected number of students to go through each course, and the reduction in training weeks between the paper-based courses and the IETM-based courses. The estimates of savings in student training costs presented in Table 7 were assigned a confidence level of "C" (Budget Quality Estimate) since they are based on student throughput projections for FY95 and FY96. The potential student training cost savings will vary as the student throughput figures change. If the actual throughput is less than the projected throughput figures, the cost savings will be less.

The FY95 student throughput figures were based on actual throughput to date and projected throughput for the remainder of the fiscal year. The FY95 throughput for the two GSE courses is 38 students. This figure is the same as the number of students shown in the GSE IETM-based courses in Table 5. The FY95 throughput for the GSM course is 49 students. This figure is the same as the number of students shown in the GSM IETM-based course in Table 6. The FY96 throughput

figures were based on the latest projections provided to SSC GLAKES school management personnel.

Table 7

Student Training Cost Savings for GSE/GSM Courses

Throughput FY95	Throughput FY96	Weekly Cost per Student ($)	Number of Weeks per Course	FY 95 Student Training Costs ($)	FY 96 Student Training Costs ($)
			GSE 302 Course		
58	72	1,146.00	Paper 5 weeks	332,340.00	412,560.00
58	72	1,146.00	IETM 0 weeks	0.00	0.00
Student Training Cost Savings			5 weeks	332,340.00	412,560.00
			GSE 328 Course		
58	72	1,199.80	Paper 15 weeks	683,886.00	1,295,784.00
58	72	1,199.80	IETM 13 weeks	592,701.20	1,123,012.00
Student Training Cost Savings			2 weeks	91,184.80	172,771,20
			GSM 303 Course		
49	180	1,360.00	Paper 17 weeks	1,132,880.00	4,161,600.00
49	180	1,360.00	IETM 14 weeks	932,960.00	3,427,200.00
Student Training Cost Savings			3 weeks	199,920.00	734,400.00
Total Student Cost Savings			**10 weeks**	**623,444.80**	**1,319,731.20**

The average cost per student per week per course was provided by personnel in the New Technologies Division at SSC GLAKES. These estimates are displayed in current fiscal year dollars. The weekly costs include student salaries, but they do not include base manning or base operational costs. The weekly costs also do not include per diem costs since not all students attending the course are on temporary duty assignment. The number of students on per diem will vary with each course convene. If student per diem costs were included, the savings would be even greater.

As part of the effort to convert the curriculum to the IETM/AC format, the course supervisors and instructors also revised and shortened the GSE and GSM training pipelines. The introduction of the IETM/AC technology provided an opportunity to redesign and rewrite some of the maintenance courses in the training pipelines.

Originally, the GSE pipeline consisted of one core course (A-652-0302) plus three strands--the FFG maintenance course (A-652-0327), the CG/DD maintenance course (A-652-0328), and AOE/DDG maintenance course (A-652-0329). Only the core course (GSE 302) and the CG/DD maintenance course (GSE 328) were included in the costs/benefits analysis. At this point, there are no plans to convert the paper-based FFG course (GSE 327) to the IETM/AC format. The paper-based AOE/DDG course (GSE 329) is in the process of being converted. The GSM pipeline consisted of one core course (GSM 303) which was included in the costs/benefits analysis.

As shown in Table 7, the GSE pipeline was reduced by seven weeks across two courses and the GSM pipeline was reduced by three weeks in one course. The GSE 302 course was deleted from the GSE pipeline. Therefore, this five week paper-based course was reduced to zero weeks in the IETM format. The 15 week paper-based GSE 328 course was rewritten to include two weeks of GSE 302 course content. However, the overall length of the IETM-based GSE 328 course was reduced to 13 weeks. Likewise, the 17 week paper-based GSM 303 course was rewritten to add two weeks of course content. But, the overall length of the IETM-based GSM 303 course was reduced to 14 weeks.

The reduction in training time in the GSE pipeline was attributed to two factors: (1) the decrease in the time instructors and students spend using the paper-based technical manuals in the classroom and (2) elimination of the core course because it covered materials that should be taught in the console operator courses and other maintenance courses. The reduction in training time in the GSM course was also attributed to two factors: (1) the decrease in the time instructors and students spend using the paper-based technical manuals in the classroom and (2) the introduction of computer-based animations to visually present concepts and enhance the instruction.

As shown in Table 7, the total savings in student training costs for the three courses is $1,943,176. The elimination of the GSE 302 course results in $630,300 in student training cost savings for FY95 and FY96. The reduction of two weeks in the GSE 328 course results in $263,956 in student training cost savings for FY95 and FY96. The reduction of three weeks in the GSM 303 course results in $934,320 in student training cost savings.

Additional savings in student training costs may be realized as other courses are redesigned for the IETM/AC technology. The GSE course 329 is currently being rewritten. A Diesel Division course (A-652-0340) with an IETM is currently under evaluation. As these courses are implemented in the five automated classrooms, the potential for savings in student training costs increases.

4.2.3 Benefit: Reduction in Course Reproduction Costs

A major aspect of managing the paper-based GSE and GSM course materials is maintaining the massive sets of technical manuals used in both the classroom and laboratory instruction. Since only two master sets of technical manuals are provided to SSC GLAKES, the technical manuals used in the classroom need to be reproduced at the local Defense Printing Service.

For the purpose of this analysis, only the reproduction costs for the technical manuals are included. Reproduction costs for other instructional materials (i.e., IG, TGs, training aids) are not included. The costs for notebooks and/or binding are not included. The costs for change pages and updates that may be issued are not included. The costs for mailing and distribution are not included. The personnel time involved in putting multiple copies of the technical manuals into notebooks, keeping them updated, and storing them are also not included.

The analysis of costs for reproducing technical manuals for the paper-based GSE 328 course and the paper-based GSM 303 course is based on the following assumptions.

- An estimate of 52 sets of technical manuals need to be on-hand for each course. This assumes that the typical paper-based classroom is set-up to accommodate one instructor and up to 25 students. The instructor and each student must have a set of technical manuals. At least two classrooms must be available for each course to handle overlapping course convenes

- The reproduction cost is an average of $0.04 per page. The cost for reproducing standard 8-12 x 11 pages may be less, but the costs for reproducing fold-out pages may be as high as $0.18 per foot.

- One set of technical manuals for GSE 328 course includes 19,553 pages contained in 34 volumes. This data was provided by the Gas Turbine In-Service Engineering Activity (GS ISEA) responsible for maintaining the gas turbine technical manuals and disseminating the manuals and updates to the fleet and the training commands.

- One set of technical manuals for GSM 303 course includes 26,608 pages contained in 43 volumes. This data was provided by the GS ISEA responsible for maintaining the gas turbine technical manuals and disseminating the manuals and updates to the fleet and the training commands.

As shown in Table 8, the estimate of the total savings in reproduction costs by implementing the IETM/AC technology in the GSE and GSM courses is $96,015. This cost estimate was assigned a confidence level of C (Budget Quality Estimate). Since the actual cost per page for reproducing the manuals may vary and the number of sets of manuals required is dependent upon course scheduling and student throughput, it is difficult to assign a higher level of confidence. However, we believe this is a conservative estimate of the reproduction cost savings that may be realized in FY96.

Table 8

Reproduction Cost Savings for GSE/GSM Courses

Course	Number of Sets of Manuals	Number of Pages per Set	Reproduction Cost per Page ($)	Total Cost for Reproduction ($)
GSE 328	26	19,553	.04	40,670
GSM 303	26	26,608	.04	55,345
Totals	**52**	**46,161**	**.04**	**96, 015**

4.3 Life Cycle Cost Model: Non-Recurring Costs

NAVSEA provided the support for funding and installing the IETM/AC technology at SSC GLAKES. Five automated classrooms were established for the GSE and GSM courses to share. Five instructor stations and 65 student stations were acquired. There is one student station in the laboratory and four classrooms with 12 student stations each in Building 238. There is one student station in the laboratory and one classroom with 15 student stations in Building 324.

SEA-04TD was responsible for refurbishing the classroom spaces and acquiring the automated classroom configuration (including computer hardware, basic software, and furniture). The Naval Sea Systems Command Automated Data Systems Activity (SEAADSA), designated as the Hardware Installation Activity, established the hardware and basic software configuration for the classrooms. The Naval Sea Logistics Center, Code 30 (SEALOG), prepared the Equipment Facilities Requirement Plan documenting the hardware/software configuration and establishing the facility requirements. The acquisition and installation activities for the classrooms were coordinated by SEAADSA and SEALOG.

The non-recurring cost estimates for implementing the IETM/AC technology in the GS "C" School are presented in Table 9. These estimates are displayed in current fiscal year dollars. There were no alternative configuration to cost at this time. However, as specifications for an automated classroom for future implementations are developed, it may be useful to compare the costs of the various configurations.

The cost for acquiring and installing the five GSE/GSM automated classrooms was approximately $2,227,000. As indicated by footnote g in the table, this figure does not include any personnel costs for course conversion. These personnel costs are considered to be implicit costs. Swope (1976) defines implicit costs as those costs attributed to the use of resources that are already owned for which there are no explicit budget allocations or monetary payments required.

The cost estimates for acquiring the instructor station, student stations, automated classroom components, and preparing and refurbishing the classrooms were assigned a confidence level of A (Detailed Cost Estimate). These costs were provided by personnel from the New Technologies Division at SSC GLAKES, who, in turn, received the cost data from the Hardware Installation Activity responsible for acquiring and maintaining the classroom hardware and software configuration.

Since a variety of issues drove the analysis, planning, and implementation of the IETM/AC technology in the GS "C" School, the cost estimates shown in Table 9 should not be considered representative of the costs for implementing the technology in other NAVEDTRACOM schools. For example, footnotes c and d in the table identify aspects of the current classroom configuration where there could be significant reductions in the unit costs. Likewise, footnote b illustrates the decrease in costs that can be expected as advances in technology are made. A systematic analysis of costs and benefits (like the process described in Section 3) should yield budget quality estimates of the potential costs for implementing the technology in a specific schoolhouse application.

Table 9

GSE/GSM Life Cycle Cost Model: Non-Recurring Costs

Non-Recurring Cost Elements	GSE/GSM Configuration		
	Unit Cost ($)	Quantity	Total Cost ($)
Student Station			
Hardware/Software	8,277.00	65	538,005.00
Work Station Furniture[a]	5,867.00	63	359,621.00
Instructor Station			
Hardware/Software	11,075.00	5	55,375.00
Work Station Furniture	7,533.00	5	37,665.00
Local Area Network	1,763.00	5	8,815.00
LiveBoard[b]	54,500.00	5	272,500.00
Link System[c]	73,995.00	5	369,975.00
Classroom Preparation[d]			
Designs	13,000.00	5	65,000.00
Computer Room Flooring	35,000.00	5	175,000.00
Installation	67,000.00	5	335,000.00
Hardware Installation[e]	0.00		0.00
User Training[f]	0.00		0.00
Course Conversion[g]	Implicit Cost		Implicit Cost
Total Non-Recurring Costs			2,226,956.00

[a]Two student stations are portable units used in the laboratories.

[b]At this time, the purchase price for the LiveBoard 3.0 has been reduced to $34,900. The higher cost here is a five year lease-to-own option that includes a maintenance agreement.

[c]The unit cost here is a five year lease-to-own option that includes the basic configuration, optional features, installation, spares, and a maintenance agreement. The purchase price can vary significantly depending on the number of student stations and the optional features included. Normally a one year warranty applies within installation done locally.

[d]These costs reflect total refurbishment of the classroom facility space.

[e]The hardware installation costs are included in the cost elements above.

[f]Initial instructor training was provided by Lockheed Martin as part of IETM database development effort.

[g]The course conversion costs are considered implicit costs since the course managers and costs for the conversion effort were not kept.

4.3.1 Student Station

The initial configuration for the student station assumed that each station would operate in a stand-alone mode. However, the size of the IETM database was much larger than originally anticipated (10 CD-ROMs versus 1 CD-ROM). The additional CD-ROMs posed the requirement for some type of expensive jukebox solution to present the database. In addition, it was too time consuming to load the software on each system in the classroom. Therefore, the decision was made

to set up a local area network (LAN) to link the instructor station and student stations in each classroom so only the instructor station (server) has to updated. The initial hardware and software configuration for the student station has been upgraded several times to reflect changes in requirements. For example, the original DX/2 66 MHz CPUs in the classrooms were upgraded with no instructional downtime.

The current hardware configuration for a student station includes:

- 486 DX/4 100 MHz CPU.
- 16 megabyte RAM.
- 3.5 1.44 megabyte floppy drive.
- 2.572 gigabyte hard drive.
- 3 X CD-ROM drive.
- 32 bit Sound Blaster card.
- 32 bit LAN card.
- 17 SVGA monitor.
- Keyboard.
- Mouse/Trackball.

The current configuration for a student station includes the following COTS software: MS DOS 6.22, Windows for Work Groups 3.11, MS ACCESS Run time, and Guide Reader. No customized software is required to view the IETM Greeter and View packages.

The student work station consists of an ergonomic chair at a flat desk with a glass window for viewing the monitor mounted under the desk. The CPU and the keyboard are also mounted under the desk to leave a clear work space with only the mouse on the surface. The work stations are available under a GSA schedule.

4.3.2 Instructor Station

The initial hardware and software configuration for the instructor station has also been upgraded like the student station to reflect changes in requirements. The instructor work station consists of a computer desk large enough to accommodate two computer systems and peripherals plus at least one ergonomic chair or stool. The furniture is available under a GSA schedule.

The current hardware configuration for the instructor station includes:

- 486 DX/4 100 MHz CPU.
- 16 megabyte RAM.

- 3.5 1.44 megabyte floppy drive.
- 6 gigabyte hard drive.
- 3 X CD-ROM drive.
- 32 bit Sound Blaster card.
- 32 bit LAN card.
- Tape Drive.
- 20 SVGA monitor.
- Keyboard.
- Mouse/Trackball.
- Laser Printer.
- VCR.

The current configuration for the instructor station includes the following COTS software: MS DOS 6.22, Windows for Work Groups 3.11, MS ACCESS, Guide, Video for Windows, and SYTOS tape back-up package. No customized software is required to view the IETM Greeter and View packages. Lockheed Martin also provided the school with the Audience Tailored Instructional Testing Environment (ATITE) and the Test Question Analysis System (TQAS) software as part of the IETM database development effort. No documentation or user training was included for these Navy owned software packages.

4.3.3 Local Area Network

Each of the GSE/GSM automated classrooms includes an EtherNet LAN (300 feet of IEEE cabling and connectors) to connect the instructor station (server) to the student stations (clients).

4.3.4 LiveBoard

The Xerox LiveBoard is an electronic white board designed for presentations and video teleconferencing. It features a 67 inch rear projection monitor with VGA resolution (640X480), an Intel 486 DX/2 66 MHz CPU, a wireless remote operation pen, full motion video, and communications software. The Windows-based MeetingBoard software facilitates connections to peripherals such as a VCR or a CD-ROM player.

The LiveBoard for each classroom was acquired from FSI Products, Inc. on a 5 year lease-to-own basis with an extended warranty to cover the lease period. Installation was included as part of the acquisition costs. Provisioning for spares was not included.

4.3.5 Link System

The LINK Video Networking System is a product of Applied Computer Systems, Inc. (ACS). The Computer Controlled LINK System (CCLS) installed in each classroom includes the individual student control units, the controller (a microprocessor, a system logic circuitry board and a 3.5 inch disk drive), and the console (a 14 color monitor) with mouse input. The following optional features are also included in the classroom configuration: Projector Control to connect to the Xerox LiveBoard, Magic Pointer and Magic Pointer Control to display free style drawing on the Xerox LiveBoard, and LINK Express (a question-answer-evaluation system that provides an instructor with immediate student feedback).

The system is hardware driven and independent of software or data LAN. The Link System is an analog overlay to the video signal. It features an on-screen classroom layout with student name or number, flexibility to re-program system software for class set-up and scheduling, automatic initialization and self diagnostics, unlimited connectivity, as well as plug-and-play installation of customized cabling routed through one single bus cable.

The CCLS is the second system at the instructor station. It provides the instructor with the following classroom management features:

- Receive--view any students display or other external device directly on the instructors monitor.
- Transmit--send the instructors display to any or all student monitors.
- Receive and Transmit--receive one students display or external device on the instructors monitor and transmit this back to any or all student monitors.
- Blank--send a blank display screen to any one or all student monitors.
- Scan--monitor every student display sequentially and automatically.
- Swap--view the displays from any two student monitors by toggling from one image to the other automatically or manually.
- Keyboard/Mouse Control--take over the operation of a students computer by using the instructors keyboard and mouse when receiving that students display.
- Keyboard/Mouse Freeze--freeze any or all student keyboards and mice to stop unwanted student input.

The LINK System for each classroom was acquired from ACS on a 5 year lease-to-own basis with an extended warranty to cover the lease period. Installation was included as part of the acquisition cost. The system is highly reliable, but provisioning for back-up power supply and interface units is suggested. ACS provides replacements for faulty components by overnight delivery.

4.3.6 Classroom Preparation

The classroom preparation costs for the five GSE/GSM automated classrooms are organized into the three categories below. The costs reflect the requirement for total refurbishment of the facility space. Requirements for other facility spaces may not be as extensive or costly as those shown in Table 4-5.

- Designs--includes blueprints, plans, site visits, contract bids, etc.
- Computer Room Flooring--includes acquisition and installation of metal framing assemblies to keep all cabling and cords under the floor.
- Installation--includes demolition, space preservation and preparation, electrical power service system upgrades, power backup unit, electrical power conditioning (ground-fault-isolation), lighting fixture upgrades, environmental and climate control systems (system controls, cooling/heating equipment, vent ducting, weather seals, registers/ diffusers, dust/dirt air scrubbers, anti-static conditioners), cable wiring and connectors.

4.3.7 Hardware Installation

Installation costs for the GSE/GSM implementation were included in the cost elements described above. User Training

4.3.8 User Training

Lockheed/Martin provided initial instructor training as part of the IETM database development and implementation effort.

4.3.9 Course Conversion

Although NAVSEA was responsible for developing the electronically enhanced IGs and TGs for inclusion in the IETM database, the course supervisors and instructional staff, with support from the New Technologies Division staff at SSC GLAKES, were responsible for rewriting the paper-based courses for conversion. The effort to redesign the courses for the IETM/AC format included preparation of view package scripts for the IETM database, development of revised IGs and TGs, and specification and development of on-line instructional materials. Since the conversion effort was performed by in-house staff as part of their daily activities, no data was kept on the level of effort or number of labor hours expended to initially redesign the courses.

The revised IGs and TGs were authored using AIM. The AIM data bases were then provided to Lockheed/Martin to extract and convert the training materials to SGML format for inclusion in the IETM database. The costs to convert the IGs and TGs to SGML format, integrate them into the IETM database, and provide the materials to the schoolhouse on CD-ROM was included as part of Lockheed/Martins overall IETM database development effort.

Although the converted IGs and TGs were integrated into the IETM database, it is important to note that the instructional materials for both courses continue to be refined and enhanced for use in the automated classrooms. Initially, the lead instructors for specific

instructional units assumed the responsibility for creating a standard set of annotations for the revised IGs. The individual instructors use the standard set of annotations and then add annotations (often in the form of visual aids) to personalize the IG as they see necessary. As experience is gained, many of the personal annotations and visual aids are being incorporated into the standardized annotation set. The instructors are also expanding the TGs to include Information Sheets in addition to Assignment Sheets. Again, no cost data was available on the level of effort or number of labor hours expended, since these activities are an integral part of the instructors daily duties.

The quality of the legacy data in the gas turbine technical manuals was a problem for both courses. Converting complex, illegible paper-based graphics and multi-page fold-out schematics into digital format often did not provide adequate quality for classroom presentation. The GSE course is currently using paper hand-outs for multi-page fold-out schematics. The GSE instructional staff is investigating several COTS graphics software packages for developing circuit diagrams (i.e., SPICE for Windows and Circuit-Maker). The GSM instructional staff has developed a number of visuals for classroom presentation using draw packages and various COTS graphics software. They have also developed detailed specifications and story boards for complex animations to enhance the instruction. The animations are developed by a contractor under an interactive courseware (ICW) development support contract managed by the New Technologies Division. Since this contract provides ICW development support across SSC training activities, data is not kept on the number of labor hours expended for specific projects. Therefore, an estimate of the number of labor hours to develop the GSM animations was not available.

The GSE course is still using paper tests rather than on-line testing. The GSM instructors converted the paper tests to an on-line multiple choice format using the ATITE and TQAS software provided by Lockheed/Martin. Even though the GSM testing has been automated, the interface with the Instructional Support System (ISS) is a manual process.

4.4 Life Cycle Cost Model: Recurring Cost Elements

Based on the data collected during the costs/benefits analysis, we could only make general statements about the annual support requirements for the GSE/GSM classrooms. These general statements are summarized below in terms of the recurring cost elements in the LCCM. An LCCM table, like the one shown previously in Table 4, was not prepared since we could not develop recurring cost estimates. Section 5.1.1 discusses the efforts that are currently in progress by several Navy organizations to define the life cycle management requirements for the IETM/AC technology.

4.4.1 Hardware Maintenance

For the most part, the computer hardware was acquired under a five year lease-to-own option with either an extended warranty or maintenance agreement included in the acquisition costs. Since the configuration is based on COTS hardware it tends to be reliable with minimal downtime. However, additional spares provisioning may be necessary over the life cycle as daily classroom utilization increases from one or two shifts to three shifts.

4.4.2 Software Maintenance and Enhancements

The current automated classroom configuration does not include any customized software other than the Navy-owned ATITE and TQAS packages. These are database oriented performance assessment tools that the user can tailor to meet specific testing requirements. If these tools continue to be used, no software maintenance or enhancements are anticipated.

4.4.3 Hardware/Software Upgrades

The costs for hardware and software upgrades that have already been installed in the instructor stations and student stations are included in the acquisition costs. However, additional hardware and software upgrades are planned. A rule of thumb that may be applied to estimate the costs for hardware/software upgrades is ten percent (10%) of the acquisition costs per student station and instructor station will be expended on an annual basis.

There are plans to upgrade the networking software to Windows NT in the immediate future. Since the Windows for Work Groups 3.11 software currently in use is a peer-based network, there are problems in maintaining the security of the instructor station software configuration and on-line testing. Upgrades to other COTS software are also expected as vendors enhance capabilities and features.

There are plans to upgrade to a Pentium processor as costs come down and more courses come on-line. The possibility of acquiring removable hard drives to store specific course configurations as more courses share the automated classroom systems has also been discussed. As technology evolves over the next few years, any number of hardware upgrades may be available to enhance capabilities.

4.4.4 Logistical Support

Maintenance of the hotel services (i.e., lighting, electrical power, heating/air conditioning) in the classrooms is the responsibility of SSC GLAKES. Both preventive maintenance and repairs should be handled through normal organizational services. Preventive maintenance activities include, but are not limited to, periodic testing and replacement of batteries in the under deck smoke detectors, inspecting fire extinguishers, replacing air conditioning filters and examining belts for wear, replacing light fixtures

In addition to classroom maintenance, logistical support also includes the costs for the following activities:

- Scheduling classroom facilities.
- Maintaining the inventory of the media/materials required to support a course in a secure space. These items include consumables, supplies, media delivery devices and spare components, multiple sets of technical manuals, training aids, instructional materials and tests.
- Reproducing the course training materials, including IGs, TGs, tests, training aids, other training/reference materials, and sets of technical manuals.

- Maintaining security and accountability in the distribution of instructional materials and tests for each course convene.

For the most part, the implementation of the IETM/AC technology should reduce the time and effort on the part of the instructional staff and/or support personnel to perform these activities. However, any reduction in these costs are more than offset by the increase in costs for system/ network administration and personnel training described in the following paragraphs.

4.4.5 System/Network Administration

The requirement for qualified personnel to perform system administration and network administration tasks cannot be overstated. Likewise, the effort required to keep the IETM/AC technology ready for classroom operations cannot be under estimated. System administration includes, but is not limited to, the following activities:

- Provide assistance to instructors and staff in solving operational glitches.
- Perform preventive maintenance, diagnostics, and troubleshooting.
- Maintain local area network.
- Maintain hardware and software configuration management control.
- Establish policies and procedures.
- Schedule classroom utilization.
- Install and load software.
- Manage the software inventory.
- Maintain physical security of classrooms.
- Maintain system security.
- Maintain system backups.
- Interface with vendors and support activities as required.

A rule of thumb that may be applied to estimate the level of effort required is one hour per week per node in a networked system. With a total of five instructor stations and 65 student stations in the five GSE/GSM classrooms this equates to approximately two full time personnel to perform system/network administration functions.

4.4.6 User Training

Continual training programs are a must, considering both military personnel turnovers and advances in technology. Management and support personnel, as well as instructors need to be trained to effectively use and manage the IETM/AC technology. Unless a civilian certified network

administrator is hired or provided by a contractor, formal training in network administration is essential for personnel assigned to that task.

4.4.7 Course Revision

As described previously, the GSE and GSM courses are in the process of being refined as new authoring capabilities and techniques are investigated as part of the R&D effort. After the IETM-based curriculum is approved by CNET, then course revision procedures documented in the NAVEDTRA 131 training manual series will apply.

Section Five

Discussion

5.0 Discussion

5.1 Implications for Future Implementations

An important aspect of the effort is to evaluate the impact of introducing the IETM/AC technology into the schoolhouse, identify the management and support requirements imposed by the technology, and develop plans to transition the technology from the R&D environment to the training community. After almost two years of experience, a number of problems and potential solutions have emerged that have implications for the costs to be incurred and the benefits to be realized in future implementations. The following paragraph summarize some of the problems and solutions encountered during the GSE/GSM implementation.

5.1.1 Life Cycle Support

NAVSEA tasked the following organizations to define the life cycle management and support requirements for the five automated classrooms at the GS C School:

- Naval Sea Systems Command Automated Data Systems Activity (SEAADSA).
- Naval Sea Logistics Center, Code 30 (SEALOG).
- Fleet Technical Support Center, Atlantic (FTSC-LANT).

SEAADSA was designated as the Hardware In-Service Engineering Activity (ISEA) and the Basic Software ISEA for the classrooms. The term hardware is broken down into two definitions. Computer hardware is defined as any piece of physical equipment including computers, monitors, desks, and chairs. Non-computer hardware is defined as any piece of physical equipment related to hotel services (i.e., lighting, electrical power, heating/air conditioning) that is necessary for the proper operation of the IETM/AC configuration. Basic software is defined as any computer program or collective group of programs that contribute to the operation of the IETM/AC (i.e., Windows and other standard software that may be loaded on the system at the time of purchase). SEAADSA is responsible for coordinating any changes in the hardware and basic software configuration for the SSC GLAKES automated classrooms.

SEALOG was designated as the Hardware and Basic Software Life Cycle Manager (Hardware LCM). Personnel are in the process of preparing a Life Cycle Management Plan that documents the responsibilities and tasks for supporting the classrooms over their life cycle. Since most of the computer hardware was acquired on a five year lease-to-own basis with five year service agreements, a life cycle of five years is assumed for the current configuration. The decision to retain, upgrade, or replace the computer hardware will be made jointly by SSC GLAKES, SEAADSA, and SEALOG.

FTSC-LANT was designated as the Software ISEA. Personnel are in the process of preparing a Software Life Cycle Management Plan that documents the responsibilities and tasks for supporting the software configuration. The software considerations include the Annotation Manager, the IETM database, and ICW.

SSC GLAKES, as the end user of the IETM/AC technology, is responsible for monitoring the condition of the hardware and software configuration, ensuring appropriate maintenance actions are taken, and coordinating with SEAADSA, SEALOG, and FTSC-LANT on life cycle support issues for the classrooms. Based on the experience of the R&D effort, it is clear that implementation of the technology imposes additional personnel support requirements on the schoolhouse. Some personnel support has been provided by vendors and contractors involved in the effort. However, most of the personnel support for the automated classrooms has been from the school managers, course supervisors and instructors with assistance from the New Technologies Division staff. Therefore, the GS "C" School managers are preparing an ASDP for submission to NETPMSA to address the additional support requirements over the life cycle of the IETM automated classrooms.

5.1.2 Acquisition Planning

Adequate planning is key to successful implementation of the IETM/AC technology. As documented in a paper presented by the Gas Turbine Technical Training Officer, LT. Eric Fretz (1995), the speed with which the technology was implemented in the GSE/GSM courses led to some early mistakes that could be avoided by more planning and discussion. For example, the size of an automated classroom was decreased to a maximum of 12 or 15 students from the maximum of 25 students in a paper-based classroom. The classroom size has implications for supporting the projected student throughput as well as classroom scheduling and system resource management. The scheduling for the IETM classrooms follows the Navy 6+2 Initiative. Six hour classroom sessions are from 0600 to 1200 and from 1800 to 2400. The two hours of either mandatory or voluntary study time are available from 1300 to 1700 for students from either session. To meet projected throughput requirements, the GSE school has three classrooms with 12 student stations each, the GSM school has one classroom with 15 student stations, and both schools share one classroom with 12 student stations.

Also, the initial hardware and software configuration did not include the use of a local area network (LAN) to link the instructor station (server) and the student stations (clients) in the classroom. When this requirement was recognized, an EtherNet LAN and Windows for Work Groups 3.11 were installed. However, this simple setup does not provide the necessary capabilities and security features so plans are currently being made to upgrade to Windows NT software. In addition to the issue of maintaining the security of the course tests and the instructor station configuration, physical security of the classrooms and management of the COTS software inventory are major concerns that need to be addressed.

Although adequate planning is essential, the process normally required for planning and implementing such technology is too time consuming. Often times the technology is obsolete before the system is installed. Management tools need to be developed to support planning and budgeting phase and facilitate the acquisition and installation phase. NAVSEA has tasked personnel at FTSC-LANT to develop a generic Equipment Facilities Requirement Plan (EFRP) and a generic Abbreviated System Decision Paper (ASDP) for use in planning and initiating future implementations. The purpose of these generic documents is to identify the basic requirements and indicate where school specific information needs to be furnished.

Personnel from SEAADSA discussed the requirement to streamline the process for procuring the automated classroom components. Efforts are underway to establish a delivery order type contract to allow schools to acquire COTS hardware and software (i.e., the LINK System and the LiveBoard) that are specified as part of the configuration and are not available under the current small multi-user computer contract or GSA schedules. This type of contract may include provisions for quantity buys, spares, installation and maintenance support, and user training. It should result in lower acquisition costs than those incurred for the R&D effort and it should reduce the lead time to order and install the equipment.

5.1.3 User Training

As described earlier, user training is critical for successful implementation of the IETM/AC technology. Appropriate user training must be provided for students and instructors, as well as course management and support personnel. The need for qualified personnel to perform system administration tasks and, especially, network administration tasks cannot be over emphasized. As stated by Fretz (1995):

> For now, the resident computer geek simply learns on the job and from vendors/installers. This corporate knowledge is perishable and puts the school up against a rock when the military member transfers. It is possible to ameliorate this situation with a GS/contracted network administrator, but continual training programs are a must. (pg. 2)

If qualified civilian or contractor personnel are not hired, then formal training programs in microcomputer hardware and software configuration management and certification as a network administrator are essential for military personnel assigned those duties.

Instructors are the primary source of innovation and key to the success of the system. They need to be involved in the process of creating the end product for use in the classroom. As part of the lessons learned, weekly instructor training programs are scheduled to share corporate knowledge, float ideas, and demonstrate proven concepts (Fretz, 1995).

To maximize the effectiveness of the IETM/AC technology, the instructors must be adequately trained on the operational features and enhanced capabilities of the technology. Since the instructional staff has varying degrees of computer literacy and experience, the initial training was provided on an ad hoc basis by the instructors with computer experience who were willing to experiment with the system. Based on this experience, the GSM course managers at SSC GLAKES have developed a 40 hour syllabus for initial instructor training on how to use the IETM/AC technology in the classroom. This syllabus will be used to train incoming GSM instructors and it is being modified to train GSE course instructors.

Members of the instructional staff may also require training in COTS applications software that is used to author the instructional materials and development multimedia training aids. As requirements and enhancements are defined and demonstration software packages are evaluated, user training should also be considered to reduce the learning curve and increase productivity.

On the first day of class, students receive approximately 6 hours of training on how to use the IETM/AC technology. The training varies depending on the students familiarity with computers. Novices are directed to go through the mouse and Windows tutorials before being introduced to the IETM on-line help index and practicing navigating through the IETM. Students concentrate on searching the database, making annotations, and creating bookmarks. Instructors report that most students are comfortable with the system and proficient in using it by the end of the first week of class. Students that continue to have trouble may receive additional assistance during the voluntary study time.

Students have the capability to use the annotation feature in the IETM database to take notes on-line at their work stations during class sessions. However, there appear to be several drawbacks to on-line note taking. Many students do not have basic typing skills and hunting and pecking on the keyboard disrupts their concentration on the course content. Since the only systems available for students to review their notes on floppy disk are the ones in the IETM classrooms, their study time may be restricted to the afternoon hours. Systems may not always be accessible after hours or over weekends. Likewise, the students may not be able to review their notes on-line after they return to their jobs in the fleet.

5.1.4 Interface with IETM Database

The Naval Warfare Surface Center, Carderock Division, Philadelphia Detachment (NAVSSES) is the Gas Turbine In-Service Engineering Activity (GS ISEA). As such, this group is responsible for managing the GS technical manuals and providing technical expertise. They worked closely with Lockheed/Martin in the conversion of the technical manuals to the GS IETM database. They also participated in the development of the view packages for the GS IETM database with assistance from the instructional staff and New Technologies Division personnel at SSC GLAKES. Even though Lockheed/Martin was responsible for developing and installing the GS IETM database in the fleet and in the schoolhouse, NAVSSES will assume responsibility for maintaining, updating, and disseminating the database in the future.

NAVSSES is currently in the process of establishing a hardware and software configuration to duplicate the IETM development facility used by Lockheed/Martin. They are also investigating techniques for improving the quality of the database. Techniques include better quality control of legacy data, improved scanning capability, converting raster scan images to a digital (ASCII/ vector) format, and evaluating the value added by view packages versus other expert models that may be developed to guide the user through the technical content.

The GSE and GSM course IGs and TGs authored using AIM were integrated into the IETM database and the link with AIM was lost. The links between IETM databases and other major Navy systems like AIM need to be analyzed to allow data from diverse sources to be dynamically managed. The schoolhouses need to retain control of the IGs and TGs and the course revision process needs to independent of the IETM development and revision process. However, there needs to be a two-way flow where updates in one set of data flag changes in the corresponding areas of the other set of data to minimize the labor-intensive manual process.

The plan is to disseminate updates to users via CD-ROM on a semi-annual or possibly quarterly basis. Updates will include changes in the technical manuals as well as database fixes

such as failed links and text and graphics errors that users identify. A system needs to be developed like the TechMan Deficiency Reports used for paper technical manuals to document deficiencies in the database. The technology should facilitate receiving inputs from both the fleet and the schoolhouse and disseminating corrections to the end users.

5.2 Potential Benefits

The statement of benefits presented as part of the costs/benefits model addressed the immediate benefits that could be analyzed and quantified in a meaningful way for the GSE/GSM demonstration. However, a variety of other benefits may be realized in future implementations of the technology in other training environments. Some potential benefits are summarized below.

Benefits in both preparing and delivering instruction may be realized by incorporating the Training Integration Management Software (TIMS), currently under evaluation in a Diesel Division course at SSC GLAKES, into the configuration for future IETM automated classrooms. This format neutral capability allows both PPP-based instructional materials authored using the current version of AIM and task-based instructional materials authored using Word Perfect to be used in the automated classrooms without the need to convert the materials to SGML. Significant cost savings may be achieved by eliminating the need to translate instructional materials into SGML format.

TIMS includes several features to facilitate instructor management of the course presentation. The software has a broadcast feature to allow digital sharing of displays in addition to the analog video linking system currently implemented in the IETM classrooms. It also incorporates a programmable remote control to allow the instructor to control the presentation from anywhere in the classroom. Although these features do not necessarily have cost implications, they may represent gains in efficiency in managing the classroom environment.

Another potential benefit may be the integration of automated performance assessment tools into the IETM/AC software configuration. Both the curriculum developers and the classroom instructors could benefit from automated test generation and scoring as well as analysis and recording of student performance. As advances in technology are made, it may be possible to streamline the process and integrate the results of automated performance assessment software with the reporting requirements of the Instructional Support System (ISS).

As documented by Fretz (1995), the GSE/GSM implementation uses the classic paradigm for group paced instruction. The instruction is presented via instructor-led lectures with the technology providing computer-controlled multimedia support. Students have on-line access to the TGs and IETM database, as well as an on-line capability to take notes, but the instruction is presented in a lock step mode. If the IETM/AC technology is integrated with self-paced instructional modules (ICW), it may be possible to further reduce the overall training time and student training costs, as well as increase operational readiness.

Section Six

Recommendations

6.0 Recommendations

1. The GSE/GSM demonstration highlights the need for coordination among a number of Navy commands and organizations. As the technology evolves and costs decrease, more systems in the fleet will be targeted for IETM development and more formal courses in the schoolhouses will be identified for conversion to an IETM/AC format. However, the roles and responsibilities of the cognizant organizations (Systems Commands, ISEA and other fleet support activities, CNET, NETPMSA and other training support activities, and the NAVEDTRACOM schools) should be better defined and procedures should be established to ensure coordinated efforts that result in the cost effective implementation of the IETM/AC technology in the fleet and in the schoolhouse.

2. To accommodate the Program Objective Memorandum (POM) budgeting cycle, the current time line for submission of both an Equipment Facilities Requirement Plan (EFRP) and an Abbreviated System Decision Paper (ASDP) is six years prior to project implementation. Considering the rapid advances in technology, the trends towards obsolescence in a few years, and the evolving nature of IETM processes and products (as documented in the survey of IETM practices conducted by Kribs & Mark, 1995), a shorter time frame between project initiation and subsequent funding and implementation should be established.

3. With the continuing introduction of technology in the fleet and in the schoolhouse, the methods and media for training are changing and the roles and responsibilities of instructors are evolving. The formal Instructor Training Schools should be revised to provide training in topics such as computer literacy and operator skills, techniques for designing and presenting computer-based instructional media, use of automated performance assessment tools, and technology-driven instructional strategies.

4. The automated classroom technology imposes new skill requirements for management and support personnel. Qualified personnel are needed to perform both the system administration and network administration tasks. The possibility of establishing a formal school to produce a Navy version of an industry certified information system manager and network administrator should be investigated.

Section Seven

References

7.0 References

Alligood, C. J. (1994). *The gas turbine systems interactive electronic technical manual (IETM): Improving maintenance and streamlining the training pipeline.* Unpublished manuscript.

Fretz, E. B. (1995, May). *Electronic classroom technology: Lessons learned from the Great Lakes interactive electronic technical manual experience.* Paper presented at the N7/N8 Workshop on the Training Benefit of the Accelerated Use of IETMs, Orlando.

Kribs, H. D. & Mark, L. J. (1995). *A survey of interactive electronic technical manuals used in education and training* (NPRDC-TN-96-35). San Diego: Navy Personnel Research and Development Center.

Levin, H. M. (1983). *Cost-effectiveness: A primer.* Newbury Park, CA: Sage Publications.

Swope, W. M. (1976). *A primer on economic analysis for naval training systems* (TAEG Report 31). Orlando: Naval Training Equipment Center, Training Analysis and Evaluation Group.

Section Eight

Distribution List

8.0 Distribution List

Chief of Naval Operations (N16), (N869), (N71)
Commander, Naval Sea Systems Command
Office of Naval Research (Code 34), (Code 342)
Chief of Naval Education and Training (Code 00), (Code 04) (2), (Code N5), (Code L01) (12), (Code 03EE1) (2), (Code N7) (2)
Commanding Officer, Fleet Anti-Submarine Warfare Training Center, Atlantic
Commanding Officer, Submarine Training Facility, San Diego
Commanding Officer, Fleet Combat Training Center, Pacific
Commanding Officer, Fleet Training Center (Code 00), San Diego
Commaning Officer, AEGIS Training Center, Dahlgren, VA
Chief of Naval Personnel (PERS-00H)
Commanding General, Marine Corps Combat Development Command (MCCDC), Quantico (Code C46), (C46MS)
Commander, Naval Training Center, Great Lakes, IL
Commanding Officer, Fleet Training Center, Naval Station, San Diego (Code 021.2)
SERVSCOLCOM, San Diego
SERVSCOLCOM, Great Lakes
COMTRALANT (Code 01A)
COMTRAPAC (Code N-31)
Pentagon Library
Defense Technical Information Center (DTIC) (4)